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MR. McMENAMIN NEW BOTANY EDITOR

Present teaching loads have brought important changes on our journal staff. Mr. A. G. Zander, our editor for botany for many years, has taken over additional work at Boy's Tech and now bids his many friends in SCHOOL SCIENCE AND MATHEMATICS adieu. His work will be taken over by Mr. Joseph P. McMenamin of Oak Park.

Mr. McMenamin had his undergraduate work in Northern Illinois State Teachers College at DeKalb, Illinois and at the University of Illinois where he received a B.S. degree in Education and the Kappa Delta Pi scholarship award. Later he studied at North Carolina State College and received the M.S. degree. He has taught for fourteen years in elementary, high, and college. In 1940 he was appointed the first state park naturalist in North Carolina and later assisted in similar work in Illinois. Among his contributions are papers in the Proceedings of the Illinois, Indiana, and North Carolina Academies of Science and translations of two German botanical papers now on file in the U.S.D.A. Library at Washington.

MISS BURGESS EDITOR OF ELEMENTARY SCIENCE

Miss Anna E. Burgess, Supervisor of Elementary Science of the Cleveland Public Schools replaces Dr. David W. Russell as editor for elementary science. Miss Burgess graduated from the New York State Normal School at Oswego and later received the Bachelor's and Master's degrees from Western Reserve University at Cleveland. She was assistant principal at the curriculum center school for arithmetic in Cleveland for five years

then principal of the elementary science curriculum center school for twelve years. In addition to her present position as Supervisor of Elementary Science she is the Ohio Director of the National Science Teachers Association. She has taught summer courses in methods in the teaching of arithmetic at Western Reserve University and at Mercyhurst College in Erie, Pennsylvania.

Send articles for this department direct to Miss Anna E. Burgess, Board of Education, 1380 East 6th Street, Cleveland 14, Ohio.

WORLD GOVERNMENT IN THIRTY YEARS

Dr. Arthur H. Compton, chancellor of Washington University, St. Louis, and a member of the American delegation to the United Nations Educational, Scientific and Cultural Organization general conference here, told a Paris audience that if we have 30 years of peace, world government will be inevitable.

Lecturing at the University of Paris, the Nobelist said technological advances are speeding the growth of a world community, and the gradual growth of international services will lead to world government in three decades of peace.

Even with an atomic arms race, Dr. Compton predicted that the great risks of destruction made peace likely. He said industrial applications of atomic energy can be expected within 10 years.

The aim of UNESCO, he declared, is to provide high aims worthy of the great powers science has produced.

GERMAN SCIENTISTS AIDING AMERICAN RESEARCH PROJECTS

In addition to the 270 German and Austrian technical experts recently revealed to be working in this country under the War Department, more are known to be here in Navy custody, but their number and the nature of their work has not been released.

Army plans call for increasing the number to approximately 1000, in the program which got underway on an experimental basis in September, 1945. Some of these alien scientists have been granted the right to apply for immigration visas and may eventually become American citizens.

Included among the "big name" scientists revealed to be in this country are Dr. Alexander W. Lippisch, former chief designer of the Messerschmidt Aircraft Co.; Wernher von Braun, credited with inventing the V-2 rocket; Dr. Friedrich Doblhoff, Vienna, designer of the world's first jet-propelled helicopter; and Dr. Helmuth Heinrich, formerly of the Graf Zeppelin Research Institute. German rocket experts are working at Fort Bliss, Tex., and nearby White Sands, N. Mex., where U. S. Army Ordnance is firing V-2's to gather scientific data. Another group of the Germans is stationed at Wright Field, Ohio, where the Army Air Forces have a large research and development center.

Many of the scientists brought publications and notes which may prove important contributions to American science and industry, the Army said.

SCIENCE, GENERAL EDUCATION, AND THE NATIONAL WELFARE*

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Detroit, Michigan
November 30, 1946

Ladies and Gentlemen of the Teaching Profession:

I am both privileged and honored to speak to you today—first, because you are working members of the most important profession of all professions; second, because I am flattered to think that you think a university president might say something of value to you with respect to your problems. Note that I use the subjunctive mood, for I am enough of a scientist to know when I don't know—enough of a scientist to abhor posing as an expert before those who are experts by virtue of direct experience.

I therefore wish to direct my remarks this morning to the broader problems of general education and the national welfare, with particular reference to science, knowing that throughout the working sessions of your conference you will have expert advice and counsel on many phases of your difficult and complex, if not impossible, job of teaching science efficiently and well.

I would first emphasize that you and I live and work in a unique society evolved during the past one hundred and fifty years, unfettered during its growth by those ancient and feudal customs and traditions of earlier periods. It is a society worth preserving. Our nation, alone among nations, succeeded in developing a democratic form of government based on universal suffrage; in developing a classless society which provides equality of opportunity for all its people.

The American social order is certainly different and better than any other order the world has seen. It has an even greater promise for the future, now that we have successfully defended it, by force of arms, against those who would have the world return to an age of tyranny. Despite the overwhelming military victory over our direct enemies, we continue the war, only now we must face and fight the unseen enemies of the American way

* Delivered at the meeting of the Central Association of Science and Mathematics Teachers.

of life, which can destroy our society slowly, yet more surely than the atomic bomb in the hands of an enemy nation.

Our unseen enemies stem from within—stem from the nature of man himself, arise from the failures of our social order, arise when the greed and selfishness of powerful groups make them forget that modern man lives in what is essentially an interdependent society—a society in which the welfare of every group of workers is dependent on the general welfare of other groups.

There are many reasons and factors which have contributed to the development of the American way of life, but chief among them is our system of universal classless education. Jefferson's conception was that the American democracy would work if, through education, the nation could provide a citizenry capable of universal comprehension and understanding and led by wise and intelligent leaders. This is the real, the primary challenge to education and it transcends all other objectives and goals we educators have before us.

The two great revolutionary forces of modern times are science and democracy. These forces dominate our age, and out of the stresses imposed by them on our society come all the major problems of the day.

Human genius through science has cleared away the barriers of ignorance and given man control over nature and his environment. Science has flooded the world with its products, enabled populations to increase, extended the span of human life, built great cities, bound the people of the world together with transportation and communication, and now even the immense energy of the atom is available for man's use.

Despite the magnificent achievements of science, we must ask ourselves—to what purpose? Are people happier, healthier, and more kind to others? Has life become more gracious, dignified, humane, more beautiful? Are people more honest or ethical in social, political and economic affairs? Are we less selfish? And do we use reason and compromise in solving the problems of human relationships?

The answer is a very feeble yes, for some progress has been made. However, almost without exception, students of the human scene point out that our mastery of the physical world is equalled only by our lack of mastery of the art of human relationships. Here is our greatest failure and the most urgent task of science and education.

Political democracy is a comparatively recent fact. Since the time of Plato democracy has had many different meanings—it still has a multitude of meanings; in fact, it has as many meanings as there are men.

One of its core meanings is it is essentially individualistic—opportunity is given to all and let the individual fail or succeed as his abilities dictate. Another conception, more broad and controversial, is that political democracy is not enough; that it is merely the instrument to use in fashioning a social and economic democracy—a state in which every man has what is needed for health and happiness, no more, no less.

These different conceptions of democracy react upon each other constantly, these different views of the objectives of a democracy provide the fundamental basis of much of our political controversy within the nation, and with other democratic states.

It is certain, however, that mankind, in establishing his governments, is primarily interested in the common welfare and this welfare will be sought by other means if democracy cannot achieve it. The security of our democracy, then, depends on making it work. Furthermore, since democracy in action requires millions of individuals to exercise the responsibility of free choice, then the general education of the individual is the supreme requirement for success. This task belongs to everyone —it cannot be left solely to school and teacher. The general education of an individual is the product of home, school, church community environment, and work experience.

The baffling social, political and economic problems of the day resulting from the interplay of science and democracy are also educational problems. Fundamentally these problems, like the educational process, center in individual human beings. Science itself is not dangerous—it is only dangerous when it is controlled by frail and selfish men.

The method of science in the hands of intelligent men has given us great knowledge and power to control the forces of nature and our environment, but if science is to help us now, it must turn its attention to human beings. We will not make much progress in education or in the improvement of our social order until we know more about the most complex phenomenon, which is man himself.

Science has studied human beings, but so far the attempt has been sporadic and piecemeal. We know much about certain

parts of the animal, but have not yet learned enough or tried to put the parts together. We have specialists in anatomy, physiology, biology, biochemistry, biophysics and psychology, sociology, anthropology, yet their knowledge is not synthesized, not put together in a way that makes it useful to those who teach, or govern, or heal.

The advancement and humanization of society is our goal—it must also be the goal of science. Since the individual is the important entity, since it is the individual who learns, thinks, acts, works, loves and hates, it is to the individual we must turn our attention.

Professor P. V. Sears of Oberlin recently defined the function of science as follows: "The sovereign function of science is not to save us from muscular or mental exertion; we need both for the health of mind and body. Rather it is to push back, so far as possible, the bounds of uncertainty which press on us from every side, to give us such confidence as we may command, to restrict disputes and uncertainties that are needless. It is no function of science to release us from obligation, but to show where obligations lie and how uncompromising their claim is upon us. There is nothing fundamentally wrong with making men more comfortable, or their living more convenient, but it is decidedly a secondary order of business."

Note that Professor Sears says the physical achievements of science are a secondary order of business. The first order of business is man himself.

In the educational system we deal with large numbers of students and we deal with them, discuss them, plan for them in terms of mythical statistical averages, such as the average student, the superior student. These statistical creatures have no real existence. Much of our educational planning is based on the assumption that human beings are pretty much the same, may be treated as an average group—likewise with social institutions, within industry, and before the law. Such assumptions, while they may be useful and perhaps are necessary as first steps, are not scientifically valid.

The plain scientific fact is that individuals are not the same. They vary far more widely in make-up, ability, interests, emotional drives, attitudes and opinions than their outward physical similarity suggests. In your educational work you deal with individuals and I'm afraid none of us will make much progress until science gives us a far more comprehensive under-

standing of individuals and we utilize that knowledge in setting the educational environment. The famous Harvard anthropologist, Earnest Hooton, said that when teachers have human problems dumped in their laps, "they use their experience, their commonsense and their humanitarianism, but they do not draw upon a science of man because there is no such thing!"

All of us here today are interested in our future national welfare, and particularly the role to be played by science. Until the war, the nation had no truly broad, well-planned national scientific program embracing all aspects of scientific work, beginning with elementary teaching and ending with research at its highest level. The issue still remains unsettled, although during the winter months of '45–'46 we saw our Congress consider and debate legislation proposing Federal support of scientific research. The McMahon bill establishing the Federal control of atomic energy was passed. The others were passed over, particularly the bill proposing a National Science Foundation.

The political and scientific debate which went on in Washington during that year was fruitful, not in terms of actual results, but because it introduced the problem to the nation, it introduced the politician and the scientist to each other's brand of thinking, each other's problems, with both striving to understand each other.

The discussion pointed up a fundamental difference in the approach to problems on the part of both the scientist and the politician. The scientist in his thinking uses a process of reasoning from facts to conclusions which fit all the facts. Oftentimes the scientific method leads to new and unexpected conclusions. On the other hand, as one wise observer pointed out, the politician reasons from conclusions into which he attempts to fit all the facts if he can. It takes inspired political thinking to produce a result which fits all the facts!

There is some precedent for the Federal Government supporting scientific research. This has been done, particularly in the field of agriculture, for many years, but the issue as to how far our Government should go in the support of a truly broad and national scientific program still remains unsettled.

During the decades before the war the prosecution of fundamental scientific research, which supplies the basic knowledge for all the applied sciences, was left largely to individual enterprise on the part of men of talent who were wise enough to know the long-term value of knowledge for our society. As a result of

our war experience with science, and on the basis of a look into the future, we now ask—can scientific work and investigation of all kinds be left to chance? The answer is, of course, no, but only provided a way can be found for the Government to support and aid science without restricting freedom of investigation and exchange of knowledge, without which science cannot thrive.

There are cogent and compelling reasons why this nation must have a national science program and not leave the matter to chance.

Our belief in the American way of life is grounded in our happy experience with it, but that experience is only one hundred and fifty years old. Throughout this brief span of years our nation has operated its institutions in an expanding economy, with new frontiers of land, increasing population, and new resources constantly opening for us. The frontier as we once knew it here has now vanished and our population is rapidly approaching a state of equilibrium. The wise man who loves his nation and its way of life might well ask whether his system can endure and flourish under the changed conditions we see ahead.

While frontiers of land and resources no longer exist, the endless frontiers of science are ahead. The unexplored realms of nature and man contain vast riches which will go to those who are wise enough to train the scientific explorers and equip their expeditions. I have no doubt that science can guarantee its part in the development of a new golden age for our people. I doubt much more the ability of our people and our leaders to govern themselves so that they may reap the benefits of science.

The world in which we live is one of cruel realities and the issue of national security is constantly with us. The national defense is no longer a matter of the size of the Army, Navy, and Air Force. It is a matter directly related to the total strength and resources of the nation, of which schools, colleges and the scientific laboratories are as vital as any other parts. That nation whose scientific stature and health are the greatest is *ipso facto* the strongest and most secure.

Finally, it is clear that the public eventually receives the benefits of all new knowledge. That which you teach today was new knowledge yesterday. The public, I believe, has a direct interest in supporting all phases of the national science pro-

gram, just as the public supports education on all levels, for the people are the final recipients.

Both industry and the universities will continue to support science—the former, because it pays dividends, and the latter, because they have the function of training scientists and teachers of science, but the magnitude and quality of the scientific work they do will ultimately depend on the support provided by the nation as a whole.

We have also reached the stage in the development of scientific knowledge when the major scientific problems of the future are of such long-range nature, such complexity, such vastness, that only the Government can make the required investment; the returns from which will not come for many years. There are vast areas of research in nutrition, physiology, psychology, psychiatry, nuclear physics, sociology and economics which require scientific talent and facilities joined together in a comprehensive intellectual and experimental attack to win the understanding of both man and nature so necessary for our future happiness.

The creation of a national science program supported by the Government is a matter of direct concern to those who teach science. Each of you must do your own thinking about it—more than that, you must act after you have reached a decision.

Whatever plans should be adopted, it is hoped they will result from the scientists, educators, and politicians working together. Any science legislation must satisfy the scientist's demand for high scientific standards, not only in theory, but also in practice. Any plan must be sufficiently inclusive in that it does not leave any essential group unrepresented. The plan must contain provisions acceptable to the legislative and executive branches of the Government, since all legislation must be so designed as to work in the political sense.

To secure the enactment of legislation providing for Federal support of a national science program requires its proponents to use successful political methods. Legislators must be informed regarding the merits to be sought and the evils to be avoided. The plan must have a vast majority of scientists and educators supporting it. All must be convinced that the plan is worth the cost. The general public must be sympathetic.

The art of government has its own special methods of accomplishing its tasks. You and I can only do what any other

citizen can do with political methods—namely, study them, follow them, practice them until the job is done.

It is necessary to sound a note of warning with respect to science legislation. When our government or any other government supports something, it exacts some measure of control. There is no such thing as controlled science, for when it is controlled, it is no longer science. We have seen the people of fascist Germany, admittedly a people of high scientific attainments, abolish intellectual freedom and pass the control of scientific thinking into the hands of a government of venal and foolish men. It can happen here, unless all of us who are interested in the scientific health of the nation become citizen politicians. Making science, education and politics work together for the national welfare is your job now.

In a scientific and democratic nation, the nature of the scientific education provided in the schools is of prime importance. I am not worried or concerned with the training of professional scientists and engineers. This type of professional training we know how to give—it can be as rigorous and thorough as we like. More difficult, yet equally important is the nature and kind of scientific training we provide for all other citizens to enable them to understand the kind of society of which they are a part, to enable them to use rational methods in the conduct of their personal affairs.

I would venture a guess that the amount of scientific knowledge, background or appreciation possessed by the ordinary, even well-educated citizen, is of an extremely limited character. It is probably even less than his knowledge of American history. In this regard you will remember the shocking results of the study made by the *New York Times* several years ago.

A special committee of the American Association for the Advancement of Science has suggested the making of a careful study of the status of the scientific knowledge and background of the American citizen. Such an inquiry has great merit and is worthy of your active support. Information of this kind, if it can be gathered, is one of the first steps in creating better science courses in general education.

There are, of course, many urgent and practical problems crying for solution, if the educational system is to meet the challenge of the times. Members of this Association represent only the scientific segment of our educational system. In this segment the recruitment and training of teachers lag far behind

the demand. The economic and social status of your profession is not good enough to interest young men and women of ability. The training of teachers in colleges and universities needs study and revision. Opportunities for advanced in-service training are lacking. There is far too little experimentation with science courses with the objective of improving methods and content.

The existence of these problems is not surprising. They have resulted from the upheavals of war, from a disordered social and economic system seeking to attain a peacetime equilibrium. For these practical problems, solutions will be found fairly soon, for I believe the public is rapidly becoming aware of them and the public wants a strong and healthy educational system above all else.

Your practical problems can be solved, but the more fundamental one involving our knowledge of the human being must await the development of a science of man. Here is the greatest challenge facing the men of education and science. Until this challenge is met, we must continue to work, to educate to the best of our ability, having a strong faith that progress is real and our goals attainable.

INFRA-RED RAY DRIES SMOKELESS POWDER

Millions of tons of smokeless powder were dried in manufacturing during the war by the use of the invisible infra-red or heat ray, it is now revealed. In the process there was not a single fire.

This is another application of a type of radiation that has come into the industries in the past decade. It is the same infra-red ray that the U. S. Army used in its snooperscopes and sniperscopes to detect night-prowling Japs, and that both Germans and Japs used for short-distance communication where wire or wireless service could not be installed. In America it was extensively used to dry the finish on war tanks in just a small fraction of the time required by older methods.

Many new applications of infra-red in the industries were presented here today to the American Society of Mechanical Engineers by Paul H. Goodell of the Trumbull Electric Manufacturing Company. He explained a speeded-up process by which complete curing of modern synthetic enamel finishes took place in about one-fourth of the time currently associated with infra-red heating.

A continuous smokeless powder drier was described by C. E. Silk and H. E. Clark of Western Cartridge Company. Drying is necessary in smokeless powder making because most materials in the manufacturing process are handled wet to lessen danger from explosions.

In operation, the damp powder after mixture is carried through the drier on a wide belt on which it is spread in a thin layer. It passes under banks of infra-red lamps. The moist air forming over it is removed by a constant circulation of air which moves in the opposite direction of the moving belt and its load of powder.

WHY NOT ABOLISH TESTS?

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"Examinations appear to be a necessary evil."[1] So says one of our influential teachers of high school science. That is a statement that frequently finds expression. Is that frequency an index of its correctness? Even if correct is it a desirable characterization of tests? Especially when spoken within hearing of students? May not this classification of examinations, be in part, educating our students to "dread" tests, to "get-out-of" examinations whenever possible and to "get nervous when taking examinations"? This is suggesting that teachers, more than they are aware, encourage defeatist attitudes in their students by the teachers' conversation about their teaching tools. The examination or test is just as truly a teaching tool as a thermometer is a tool for use in checking health conditions by a physician. The doctor doesn't call his thermometer a "necessary evil." He rather seeks to have his patient form the habit of using it as a means of getting more accurate information in regard to his physical well-being.

Are we justified in saying, "Daily observation of pupil reactions to various assigned lessons (removes the need) . . . for examinations."[1] Studies[2] have shown that "Oral examinations are highly unreliable and of no such validity as might be hoped." This statement referred to graduate examinations. But is it creditable to think that less formal oral testing in the class room would have greater reliability or validity? One wonders if the persistence of the idea that "a teacher in the school room becomes endowed with a semi-omniscient power of evaluation" doesn't belong with the well known fallacy that one can form a reliable estimate of personality by merely looking at a photograph of a person?

Some considerable divergence has been found between rank-order given students by their high school teachers and that established by achievement and aptitude tests taken when the high school students enter college. A part of the divergence is undoubtedly attributable to the variable size of the senior classes of different high schools. In many of the high schools the

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[1] Smith, Herbert R. "Examinations of Educational Value." *The Sci. Teacher*, 9, 24 (April, 1942).

[2] Pressey, S. L. and Coworkers. *School and Soc.*, 30 (Nov. 23, 1929); *Jour. Higher Educ.*, 3, 26 (May 1932).

number of students in the senior class is too small to give an adequate sampling. Some teachers, however, believe the unreliable personal estimates formed from "daily observation," is partly responsible for this divergence. If high school teachers generally consider tests to be a "necessary evil" this personal estimate is probably a heavily weighted part of the basis for the high school's choice of the upper quartile and other categories of its students. This practice will undoubtedly persist. Even so, it is desirable to keep in mind there is very creditable grounds for believing that ranking students by class room observation is too often an expression of teacher prejudice rather than pupil merit.

A poll[3] of college teachers in regard to their examinations reported thirty per cent of them quite satisfied with current practice and obviously doing nothing about the "evils" of the system. Does this mean they do not see the "evils" or have they become cynical about the whole matter? An inventory of SCHOOL SCIENCE AND MATHEMATICS, and other magazines serving high school teachers, supports the inference that high school teachers, too, are doing little to remedy the "evils" of the examinations. If there is genuine concern about the "evils" of the examinations there should, at least, be more frequent protests appearing in high school teachers' journals.

Is it possible that part of the tension between the craftsman and his tool may be due to a narrowed estimate of the service which examinations may render the school population?[4] Conversations with teachers, too often, have left the writer with the impression that the whole service of the examination was achieved when it gave marks that "failed" or "passed" the students for that course. With that sort of salesmanship used on students is it any wonder that they sing their "Examination Hymn."

> "Shall I be carried to the skies
> On flowery beds of E's
> While others fight to win the prize
> And sail through bloody C's."?

The writer sat with a committee on college examinations recently. In the course of its session one member proposed (seriously) that a course grade should depend wholly upon the single two-hour final examination. It is encouraging to report

[3] Hendricks, B. Clifford and Handorf, Benjamin. "Examination Practice in General College Chemistry." *Jour. Chem. Educ.*, 15, 179 (April, 1938).

[4] McConn, Max. "Examinations: Old and New; Uses and Abuses." *Educ. Record*, 16, 375 (Oct., 1935).

that his exalted confidence in a single examination was not supported by other members of the committee. Such an overemphasis of a single examination when imposed upon students in a class can be just as unfortunate in its effects as a continuous labelling of tests as "evils." There is a disposition upon the part of some students to consider the final examination as a sort of "tool of inquisition" used by the teacher to "break" the student scholastically. Such a student attitude is not allayed by publicising a final examination as the sole determiner of the grade in the course.

Doctor Morrison[5] has very well characterized a good teacher as "(spending) half of his time studying his pupils as growing individuals and the rest of the time in doing what that study indicates is desirable and necessary." Most up-to-date teachers will give "lip" assent in support of testing as a means of pupil study. Growth, all will recognize, brings change. Both teacher and pupil want to know, not only that there is a change, but wish to know the extent of that change. They should be much concerned as to the validity, i.e. fitness, of the indicators (tests) used as a gauge of the extent of the change. Dr. Pressey and co-workers found that oral test procedures do not give a rank-order for students that is reproducible by further oral testing. If their findings are correct it would seem obvious that a break from the hunches and intuitions of "Hoosier Schoolmaster" days, may be in order, and a search made for a plan that has more evidence of reliability.

Why Not Abolish Tests?

Not because they are "evil" for their disrepute comes, much of it, by unintentional adverse gossip of pupils and teachers.

Not because class room estimates made by a teacher make them unnecessary for such oral evaluations have been shown to be of questionable validity and of uncertain reliability.

Not because great efforts to correct their shortcomings have been fruitless for it appears there has been little well directed attention to their improvement.

Not because their service toward subject-matter achievement is extremely limited. Even a superficial analysis of teaching procedures makes proper tests appear imperative to their realization.

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[5] Wood, Ben D. "The Major Strategy of Guidance." *Educ. Record*, 15, 11 (Oct., 1934).

FORESTS AND PEOPLE*

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The close relationship that exists between forests and people is one that I should like to present by a few specific examples rather than in glittering generalities. I hope that you will pardon me if I use the first person rather freely in doing so. Suppose we start with a chapter out of my daily life.

I live in what looks like a brick house, but actually its frame is constructed almost entirely of wood. I slept last night in a wooden bed. When I woke this morning, I looked at a wall covered with paper made from wood pulp, and at pictures framed in wood and hung from a wooden molding. The paint on the wooden door which I opened on my way to the bathroom contained turpentine from a southern pine tree and oil from a tung tree. My socks and ties were made of rayon that originated in a spruce forest. The leather in my shoes was tanned with an extract from oak bark.

I walked to the dining room on wooden stairs and wooden floors, and ate my breakfast sitting in a wooden chair at a wooden table. My orange came from a wooden crate, my cereal from a paperboard container, my drink from a coffee tree, my sugar from a maple, and my paper napkin from an aspen. The newspaper that I read, except for the ink, was almost entirely a product of the forest. The plastic ash tray at my elbow consisted largely of wood flour, as did also the linoleum which I presently swept with a wooden-handled broom. Even the soap with which I washed the dishes contained rosin from the same kind of pine that produced the turpentine for the paint.

At my office I sat in a wooden chair at a wooden desk; read documents from wooden file cases; wrote with a wooden pencil on paper made from wood pulp; and dictated to a stenographer in a rayon dress. On my way to Detroit I saw freight cars made partly of wood running on wooden railroad ties. I passed hundreds of poles carrying wires for the transmission of power and of telephone and telegraph messages. The older tires on my automobile were made of natural rubber from a rubber tree, while the newer ones were made of synthetic rubber manufac-

* Delivered at the meeting of the Central Association of Science and Mathematics Teachers, Detroit, Michigan, November 30, 1946.

tured from alcohol produced by fermentation of sugar that had once been cellulose in a Douglas fir tree. The milk shake that I had on my arrival was flavored with vanillin made from the waste liquor at a wood-pulp plant.

This sketchy list of some of the ways in which one person has come into contact with products of the forest in the course of a few hours will perhaps illustrate sufficiently one of the relationships between forests and people. We hear much of the substitution of other materials for wood; yet wood is not only holding its own for many purposes but is constantly finding new uses. So diversified are the uses to which it may be put that the Germans have dubbed it "Universalrohstoff"—the universal raw material. Whoever we are, and whatever we do, the products of the forest enter into our daily lives in innumerable ways, some obvious, others generally unsuspected.

In addition to the contributions which they make to our personal comfort, the forests are the basis for much of our industrial activity. It may surprise you to know that the wood-using industries rank high among all manufacturing industries in number of establishments, number of men employed, wages paid, and value of products. They provide widespread opportunity for the profitable employment of labor and capital, and are the chief source of prosperity for many a community. That prosperity may, however, be short-lived unless the forests are so managed as to maintain a continuing flow of raw material for industrial use. Let me illustrate this fact by a true story.

Fifty years ago a primeval forest of hemlock and hardwoods covered much of north-central Pennsylvania. Part of this, known as the "Black Forest," was so dense that the reading of a newspaper in its shade at high noon was said to be difficult. Here in 1895 the Lackawanna Lumber Company started logging and milling operations. Almost overnight these resulted in the appearance in the hitherto unbroken wilderness of the hustling town of Cross Fork.

The main support of the town was the big sawmill, which burned down twice, to be replaced each time by a bigger, busier, and better mill. In its final form it turned out approximately 72 million board feet of lumber a year with a value of about a million dollars. Smaller industrial establishments included a planing mill, lath mill, kindling mill, shingle mill, hub factory and machine shops.

Cross Fork itself rapidly expanded to a population of some

2500 persons, with an additional 5000 lumberjacks in the neighboring woods. The general store run by the Lackawanna Lumber Company had a larger trade than any other store in the county. Yet it had plenty of competition for there were also five independent groceries, a dry-goods shop, a millinery shop, two clothing stores, a shoe store, two drug stores, a hardware store, a sporting goods store, and numerous other retail establishments. There were three doctors, a dentist, and two undertakers. Seven hotels offered welcome to the traveler, while three restaurants, one of which advertised to purvey anything that Delmonico's did, ministered to the inner man. The town's religious, educational, and social needs were met by four churches, a W.C.T.U., a Y.M.C.A., an exceptionally fine high school and grade school, several fraternal organizations, an opera house, and a weekly newspaper.

But the forests on which all this activity depended were not inexhaustible. In the short space of fourteen years they were completely cut out. The big mill closed down in the spring of 1909, and by autumn the exodus from the town was in full swing. One of the hotels burned down in June, another in July. From then on sporadic fires were fairly common until in February, 1910, a whole block was destroyed. Thereupon the insurance companies cancelled all existing policies, and fires were replaced by a series of forced sales. Five-room frame houses with steam, water, and bath were offered for $25, and seven-room houses for $35, without finding a buyer.

In the fall of 1913 the Buffalo and Susquehanna Railroad, which for some time had been running only three trains a week, discontinued its service entirely and the next spring tore up its rails. That was the *coup de grâce*. Cross Fork was dead. In five years both its population and the assessed value of its real estate had decreased by 98 per cent. The town had disappeared along with the forest on which its existence depended. Different management would have made possible a smaller but more permanent community.

In addition to industrial raw materials, people are indebted to forests for many other products and services. These include forage for livestock production; wildlife for the control of insect pests, the provision of food and fur, and the enjoyment of hunters, fishermen, and other lovers of the outdoors; water for irrigation, power, navigation, and municipal use; checking of floods; prevention of erosion; amelioration of climate; and op-

portunities for physical rejuvenation and spiritual inspiration. It has been said that we could get along reasonably well without wood but not without forests. In spite of its exaggeration this statement contains an element of truth. Let me illustrate some of these other values, and the dangers to which improper forest management exposes them, by another story or two.

Trail Creek in central Colorado was originally a clear stream confined to a narrow channel and with comparatively little erosion. Gradually, however, the character of the stream changed as a result of heavy cutting and fires on the forested watershed where it rose. Floods became more frequent, erosion set in, the stream bed was widened, and its bottom began to fill up with sand and gravel washed down from above. In April, 1914, a heavy flood caused serious damage to a previously prosperous ranch at the mouth of the creek. Approximately a fourth of the irrigated land on the ranch was ruined by being buried under 18 to 30 inches of coarse gravel; the irrigation ditches were completely filled; and the course of the stream was so changed as to prevent the further use of water from it for irrigation. The next year another flood washed out several acres of hay land, ruined some 16 tons of hay, and piled gravel $2\frac{1}{2}$ feet deep against the kitchen door.

Agriculture in central Utah is confined to a narrow strip of land which can be irrigated with water coming from the Wasatch Mountains immediately to the east. For 75 years the mountain water continued to be available with only minor irregularities in flow. Prosperous farms and communities developed. Then on August 13, 1923, came disaster. Thick, slimy mixtures of water, soil, and rock coming from several steep canyons in Davis County swept everything before them. Houses were crushed like match boxes; orchards and crops were destroyed; farm lands were covered with mud, gravel, and boulders weighing as much as 200 tons. Six lives were lost and property damage ran into the hundreds of thousands of dollars.

Similar floods in subsequent years led to a thorough investigation which proved that they were due to the destruction of vegetation on steep slopes by fire and excessive grazing. Steps were promptly taken to control these destructive agencies, contour trenches were constructed to check surface runoff of water, and the denuded areas were seeded to perennial vegetation to help still further in reducing runoff and holding the soil in place. Two heavy rainfalls since these control measures were under-

taken have resulted in practically no damage. People who inquired incredulously whether 200-ton boulders could be anchored by grass, brush, and trees have had their question answered in the affirmative.

On a prairie farm in western Kansas the owner was rapidly losing all of his fertile top soil by wind erosion. Crops were poor, living conditions uncomfortable. After every windstorm the housewife had to shovel the soil from the porch and sweep it from the interior of the house, while the county had to plow out an adjacent highway almost continuously in order to keep it open for travel. Today the picture is completely changed as a result of shelterbelt planting and consequent soil stabilization. Crops have improved, livestock is protected, wildlife has appeared, the outlook is more attractive, living in general is more comfortable.

Northern Michigan is a favorite mecca for tourists in large part because of its forests. When you or I decide to go automobiling, or camping, or picnicking, we ordinarily seek a place where there are trees to provide shelter and pleasant scenery. We like to cook our food over an open fire burning wood fuel that we have collected ourselves. And there is a quality about the forest that provides relaxation and inspiration for those who are weary in body or in spirit.

Possibly these various relationships between forests and people can be summed up in a bit of doggerel that I wrote some twenty years ago, with due apologies to numerous authors who have written in similar vein.

What do we plant when we plant a tree?
A thousand blessings for you and me—
We plant the lumber to build us a house,
We plant a cover to harbor the grouse;
We plant the fuel to kindle our fire,
When strikes the prices of coal send higher;
We plant for fences the posts and rails,
We plant a shelter to temper the gales.

We plant the pencils to scribble our notes,
We plant the ballots to cast our votes;
We plant the paper in which to read
The news that o'er wooden poles we speed.
We plant the piles to erect our docks,
We plant the rayon for shirts and socks;
We plant the extract to tan our shoes,
We plant 'most anything you choose!

We plant the barrel, the box, the crate,
In which to ship all sorts of freight;

We plant the cars to carry the grain
The farmers raise on the western plain;
We plant the sleepers under the track
O'er which we send our products back;
We plant a blanket to hold the soil,
We plant good wages for those who toil.

We plant a forest sponge to check
The menace of the wild flood's wreck.
We plant refreshment, rest, and health;
We add our share to the nation's wealth.
We plant a stately cathedral where
To worship God in the open air.
Beauty, contentment, prosperity,
All these we plant, when we plant a tree.

Now of course all these stories and verses have a moral. It is simply this: that if we are to continue to enjoy the products and services that forests have to offer, they must be so handled as to maintain their productivity. Since trees grow and reproduce themselves, this is entirely possible though by no means easy. Real effort is required, as is the case in any worth-while undertaking, to protect, manage, and harvest the forest so that each new crop will be at least as good as that which preceded it. So far we have not succeeded in this country in attaining the kind of management that every one agrees to be desirable. Taken as a whole, the forests are still going downhill both in quantity and in quality.

You may be wondering what you personally can do about it. Probably most of you do not own any timberland and have no strong influence with any one who does. If that is the case, there are still three highly useful things that you can do. You can make sure that no forest is ever the worse for your presence in it; you can join with others in obtaining the adoption of satisfactory forest policies and forest practices; and you can arouse in the children whom you teach a determination to use their influence to see to it that the forests continue permanently to play the part they should in the economic and social life of the nation.

Forest fires are still one of the greatest menaces to full forest productivity. Except for lightning, which is an important cause of fires in many parts of the West, they are due almost entirely to human carelessness, particularly on the part of tourists, campers, and smokers. The least you can do when in the woods is to make sure that no conflagration is caused by any match, cigarette, or camp fire over which you have control. And if you

are considerate of others, you will see to it that the beauty of the forest is not marred by the indiscriminate cutting of trees and shrubs, the picking of rare flowers, or the scattering about of waste paper, tin cans, and other trash.

Experience throughout the world has demonstrated that government participation in the management of forest lands is essential if the interest that all of the people of a country obviously have in them is to be adequately safeguarded. That participation may take the form of public cooperation, public regulation, and public ownership. All of these activities, which may be on a national, state, or local level, have their place in any comprehensive program.

You can play an important part in the development of such a program by your support of policies that seem to you wise and your opposition to policies that you think unwise. Perhaps one of the best ways of keeping yourselves intelligently informed on the issues involved, and of making your influence most strongly felt, is through membership in one or more national or state organizations that are actively engaged in studies of the forest problem and in attempts to bring about its constructive solution. One of the most prominent of such organizations is the American Forestry Association, which has just completed a thoroughgoing appraisal of our forest resources and is now formulating a comprehensive forestry program for the nation.

Most of all you can render effective service by informing the children whom you teach of the numberless ways in which forests contribute to the well-being of the nation and of its individual citizens, and by arousing in them a desire to do their part in maintaining an adequate and permanent supply of forest products and services. The field is so broad that the opportunity to do so exists in connection with the teaching of almost any subject, including mathematics and the sciences. I can think of no phase of your work that in the long run is likely to yield larger dividends.

A VACUUM CLEANER FOR THE CAR

Vacuum cleaner, small enough to be kept in the glove compartment of an automobile, operates off the engine manifold vacuum when the car engine is run at idling speed. Connections are long enough to permit the use of the cleaner in any part of the car's interior.

THE GROWTH OF POWER AND ITS ECONOMIC SIGNIFICANCE*

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1. How Science Has Created a Social Revolution

As far back as one can see into the history of the past there have been men who have shown an interest in discovering the secrets of the natural world. Such men we have called scientists. For example, there is Eudoxus (4th century B.C.), one of the first of the long line of astronomer-mathematicians, Aristarchus (3rd century B.C.), the Copernicus of the ancient world, Archimedes (287–212 B.C.), greatest of all the scientific men of classical times. But the work of these men and their modern successors has never intrigued the public fancy in a measure comparable with that accorded the social and political events of any age and the people associated with them. In Thomas Carlyle's *Heroes and Hero Worship* (1840) we find the hero as priest, the hero as a god, the hero as a king, the hero as a man of letters, but there is no evidence that the man of science is regarded as a hero. There has been at times even fanatical hostility to his work as one finds in the savage words of the French tribunal when it condemned A. L. Lavoisier (1743–1794) to the guillotine: "The Republic has no need for scientists."

There are many reasons for this attitude toward the scientist and his work. He is an austere character; his discoveries often seem to be the work of black magic; he frequently produces theories which challenge general popular belief; he is sometimes an unpleasant fellow for he will get the better of an argument with his tables of data and his pages of formulas; he appears to work more for the glory of discovery than for the goal of gain; and he is a great fool since he publishes his discoveries free that the world may read and benefit by them. In a word he does not care a tittle for the accumulation of power, which is the general goal of political leaders. His code of life has been expressed by Henry Poincaré as well as by anyone else, perhaps, when he said: "The scientist does not study nature because it is useful; he studies it because he delights in it, and he delights in it be-

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cause it is beautiful. . . . Intellectual beauty is sufficient unto itself, and it is for its sake, more perhaps than for the future good of humanity, that the scientist devotes himself to long and difficult labors."

But during the last few decades, imperceptibly if one observes the change from day to day, but in a truly astounding manner, if a longer view of the situation is taken, the scientist has created the greatest social revolution in the history of mankind. Probing the mysteries of the tiny electron, he invented the vacuum tube which through the endless variety of its uses has done more, perhaps, to ameliorate the living of the world than the work of all the social agencies from the beginning of time. The publication of the first table of mortality by Edmund Halley (1656–1742), astronomer of note and friend of Sir Isaac Newton, combined with the development of the laws of probability, brought into the world the great edifice of life insurance which as a source of social improvement can scarcely be estimated. These instances could be multiplied without end to show the vast changes which have been wrought in our civilization by the steady accumulation of exact knowledge and its interpretation by the scientists.

Although the great congeries of lay people, whom we know as the general public, may have been aware that a strange force was working in their lives, their restricted view of the past has made any common recognition of the changing conditions of life impossible. Only the broad vision afforded by the methods of statistics can bring realization of the immensity of the progress that has been made by the ever-so-certain development of scientific knowledge.

Not by kings or emperors, by prime ministers or cardinals, has this change come in human lives. Nor among those whose decisions have appeared to alter the course of human progress, has there been numbered, except in very rare instances, a member of the scientific fraternity. In contemplating the good life and the erection of an ideal state which could accomplish this desirable end, Plato some twenty-three centuries ago put into the mouth of Socrates these words: "Until philosophers are kings, or the kings and princes of this world have the spirit and power of philosophy, and the political greatness and wisdom meet in one, and those commoner natures who pursue either to the exclusion of the other are compelled to stand aside, cities will never have rest from their evils—no, nor the human race, as I

believe—and then only will this our state have a possibility of life and behold the light of day." But the world has rejected these words of wisdom and as Gibbons has aptly said: "History . . . is, indeed, little more than a register of the crimes, follies, and misfortunes of mankind." It is perhaps not merely coincidence that the years which mark the highest point reached by the Roman Empire in peace and prosperity fell within the reign of the Emperor Marcus Aurelius, one of the few philosopher kings of history.

Among the many conspicuous achievements of science there is one that stands out fully as prominently as any other. This is the development of power. Since power, precisely defined, means the capacity to do work or to use energy, the development of power is essentially a consequence of the discovery of the nature and the sources of energy. Without the basic experiments of Michael Faraday (1791–1867) which brought magnetic and electric forces into a single discipline, there could have been no electrical industry as we know it today. Without the researches of James Watt (1736–1819) and his successors into the nature of steam and the properties of thermal energy there could never have been created the gigantic turbines which have contributed so fundamentally to our industrial growth. Hence in looking with speculative eye at the future we must examine carefully the scientific achievements of the present, which in their turn will be converted into the practical achievements of engineering and industry. In this way only can we hope to appraise the economic significance of power and what it portends for the future.

2. A Small Problem and Its Astonishing Consequences

In order to illustrate how unexpected consequences follow from the curiosity of scientists about small matters, we shall examine a special investigation which turned out to have a tremendous influence in the growth of power. Probing into their test tubes, developing their formulas, erecting their complicated mazes of glass tubing, the scientists in the early years of the twentieth century were certainly unaware that they were creating a social revolution. The special problem which we shall discuss here was on the surface only an interesting puzzle. And even the wildest imagination would never have seen the dramatic consequences that followed from it.

As early as 1897 the British physicist J. J. Thomson had

shown that the electron, then newly discovered, could be deflected by electric and magnetic fields. A series of investigations were then initiated, principally by Thomson, W. Kaufmann, and A. H. Bucherer, to determine by the methods of electromagnetic deflection the numerical value of the ratio, e/m, where e is the electric charge of the electron and m is the mass. A most interesting and curious discovery was soon made, namely that as the velocity of the electron was increased, the expected deflection in its path made by the electric or magnetic field differed from the one actually observed. This anomalous behavior was soon traced to the astonishing fact that the mass of the electron increased with its velocity.

Once this observation had been established experimentally, the mathematical physicists began an intricate examination of the phenomenon to discover the actual law of mass growth. Three theories were advanced, one by M. Abraham, a second by A. H. Bucherer, and a third by the Dutch physicist, H. A. Lorentz, all of which differed slightly from one another. This difference was not great enough, however, so that a choice could be made between the three theories by the velocities then available in the laboratories of the world. But the theory of Lorentz was derived from a very peculiar new philosophy of space and time which had been published in 1905 by a young man, then only 26 years of age, called Albert Einstein. In the long history of science there has never been promulgated a theory which seemed so remote from practical affairs and so certain to find its ultimate place in the dusty archives of metaphysics.

Through a mysterious constant, designated by c and identified with the velocity of light, space and time were united in a single equation. But this new theory indicated that the formula proposed by Lorentz gave the correct relationship between mass and velocity. This relationship states that if m_0 is the mass of the electron, when it is not in motion, now called the rest-mass of the electron, then its mass, m, when it is moving with a velocity v, is given by the formula:

$$m = \frac{m_0}{\sqrt{1 - v^2/c^2}}.$$

Who could possibly have seen in this simple result, interesting as it was, that the consequences which follow from it would in less than half a century bring to an abrupt conclusion one of the most savage wars in the history of the world and give man the

possibility of controlling power far beyond anything that he had ever dreamed about before.

Sir Isaac Newton in his *Principia Mathematica* (1687), some believed with prophetic vision, defined force as the time rate of change of momentum, that is to say,

$$F=\frac{d}{dt}(mv),$$

where the mass is included along with velocity under the derivative sign. Some slight credence can be given to the idea that Newton saw more in this formula than his contemporaries from an unexplained question in his work on *Opticks* (1704) where he asks in Query 30: "And among such various and strange transmutations why may not Nature change bodies into light, and light into bodies?"

However that may be, let us introduce our variable mass, which now depends upon velocity, into the formula for force and compute energy. If we designate energy by E, and define energy, equivalent to work, as the product of force by the distance through which it acts, we then get the following:

$$E=\int F\,dx=\int Fv\,dt=\int\left(m\frac{dv}{dt}+v\frac{dm}{dt}\right)v\,dt,$$

$$=\int mv\,dv+\int v^2\,dm.$$

We now replace m in this expression by the formula given above, which, for convenience we write as $m_0(1-\beta^2)^{-1/2}$, where we use the abbreviation: $\beta=v/c$. We then obtain the following:

$$E=\int_0^v m_0 v\,(1-\beta^2)^{-1/2}\,dv+\int_0^v m_0\beta^2\,v(1-\beta^2)^{-3/2}\,dv,$$

$$=m_0\,c^2\left[(1-\beta^2)^{-1/2}-1\right]=c^2(m-m_0).$$

That is to say, we have derived an equivalence between mass and energy.

Strange as this formula appears, nevertheless it is equivalent, when velocities are small, to the usual definition of energy. To see this let us assume that v is small with respect to the velocity of light. Then we can replace $(1-\beta^2)^{-1/2}$ by the first two terms of its expansion, namely, by $1+\frac{1}{2}\beta^2=1+\frac{1}{2}v^2/c^2$. When this is substituted in the formula for E we get the expression found in all text books of physics, namely $E=\frac{1}{2}mv^2$.

But the revolutionary aspect of this formula is found in the fact that for the first time energy was represented as a kind of mass itself. No longer could energy by itself and matter by itself be regarded as separate entities. Here at last was a theoretical indication that a bond existed between the two most conspicuous things in the universe. Energy was proportional to mass and the factor of proportionality was the square of the mysterious velocity of light. So revolutionary was this idea and so strange the metaphysical theory which led to its discovery that for some time there was reluctance in the world of science to accept these matters. To paraphrase Lewis Carroll: "It takes practice to believe impossible things." Thus we find that the Nobel prize was not given to Einstein until 1921 although his theory was published in 1905. Even as late as 1926 a debate on the theory of relativity was held between scientific men, and a conference reviewing the evidence of the Michelson-Morley experiment on the so-called ether drift, which had led to Einstein's musings, was held in 1928.

3. The Art of Alchemy

The relationship between matter and energy which had been one of the most spectacular consequences of the theory of relativity gave promise that some day man might unlock the secret of the atom and thus attain a supply of energy of unimaginable proportions. Lecturers who advanced this theory were greeted with polite skepticism. The dream seemed so far from reality that even the journalists were afraid to strain the credulity of their readers by describing the consequences. Scientific men, who advance cautiously into the unknown regions of their science, took note of the possibilities, but demanded some direct evidence for the correctness of the theory.

This proof was finally supplied as the result of a long series of experiments initiated by Sir Ernst Rutherford and his associates in the early years of the twentieth century. Perhaps the first actual indication of the truth of Einstein's formula is found in Rutherford's experiment reported in 1919 where the bombardment of nitrogen by the alpha particles from radium knocked out protons from the nitrogen nucleus and hence transmuted this element into oxygen. The velocities of the protons were greater than could be accounted for by any other theory. This is another curious fact in this strange history for Rutherford and his associates belonged to that long line of investigators known as

alchemists. About their work Ben Jonson wrote scornfully in 1610: "I'll believe that Alchemy is a pretty kind of game, somewhat like tricks o' the cards, to cheat a man with charming." And Gibbon, nearly two centuries later, describing the activities of Arabian chemistry, remarked that "the reason and the fortunes of thousands were evaporated in the crucibles of alchemy, and the consummation of the great work was promoted by the worthy aid of mystery, fable, and superstition."

But the work of the modern alchemist, while it has achieved in a measure the goal of the ancient alchemists to convert one element into another, has had in recent years a much more valuable objective. It has sought to obtain the energy of the nucleus of the atom and hence, through opening a vast new source of power, promises to elevate once more the standards of living of the world. Its scientific interest resides in the vindication of the mass-energy equivalence and the deep-seated theory of Einstein. While the achievement of the dream of the older alchemist to convert base metals into gold would have beggared princes and caused a temporary panic in the exchanges of the world, the goal of the modern alchemist offers a brighter hope, the attainment of a wealth of energy at the expense of a small in-put.

The story of the final conquest, the fission of uranium, the construction of a weapon which multiplied by a factor of approximately two million the most powerful explosive hitherto created by the arts of chemistry, is too well known to repeat here. But in it we find a terrible vindication of the mass-energy formula whose genesis we have described above. It is one of the strange ironies of fate that Einstein, the man who expressed so deep-seated a hatred of war in his volume *Why War?*, published in 1933, should be the author of the theory which lies at the heart of the most fearsome weapon ever devised by man.

And now at last the quiet scientist, the deviser of formulas, the impractical dreamer, has assumed a strange and awesome shape. Like Aladdin of the Arabian tales of long ago he has rubbed a magic lamp and the genie has emerged from his bottle in a pillar of smoke and fire. And so long as man survives this genie can never be returned to his prison. The man of science is perhaps more shaken than the common man by this event for he knows from his data what it can portend. In approximately 6.5 tons of uranium-235 or of plutonium he can by present methods generate energy equal to all the energy generated by the electrical equipment of the United States in a normal year.

And the present knowledge of these nuclear transformations recovers only one-tenth of one per cent of the energy promised by the Einstein formula. Here, indeed, we have a source of power that far transcends the wildest flights of the imagination.

Up to the present time the sources of power which we have used have been derived from relatively inefficient sources when compared with the atomic power now within our sight if not actually within our grasp. The chemist in his remarkably varied transformations and in the exchanges of energy which he effects

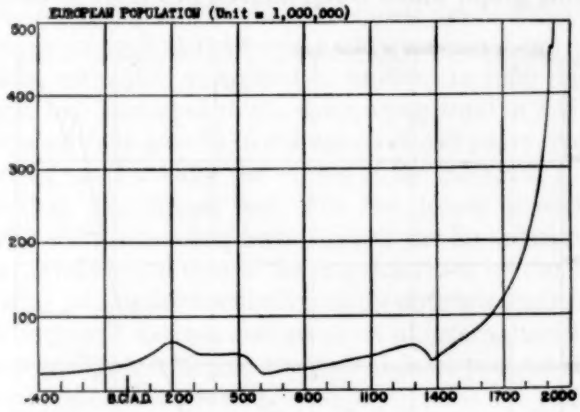

FIG. 1

has made use of the shells of electrons that surround the nuclear core of the atom. The burning of a ton of coal is what might be described as a chain reaction in which the valence electrons of the carbon combine with the valence electrons of oxygen to form the oxides of carbon. The energy extracted from the burning of a ton of coal is of the order of 7,600 kilowatt hours. But the energy extracted from the fission of a ton of uranium is of the order of twenty billion kilowatt hours, while that from the complete annihilation of a ton of matter (not yet accomplished) is of the order of twenty trillion kilowatt hours. We thus see the incomprehensibly greater energy that resides in the depth of the atom as compared with that in the peripheral shell of electrons with which the chemist has constructed his science.

4. POWER AND POPULATION

Let us turn next from this dream of power to another and perhaps more important matter, the impact of this dream upon

the human state. Now that the scientist has shaken the ordinary world by his discoveries he is no longer to be left in the isolation of his impractical musings. Bayonets guard his laboratories and he must clear his thoughts with the FBI. His former practice of publishing for all to read is restricted by the censorship of government, which has come to fear his thoughts above those of other citizens. And well it might for the destiny of mankind is in his hands.

In order to obtain a broad view of the situation, let us examine the striking graph which is reproduced in Figure 1. Based upon

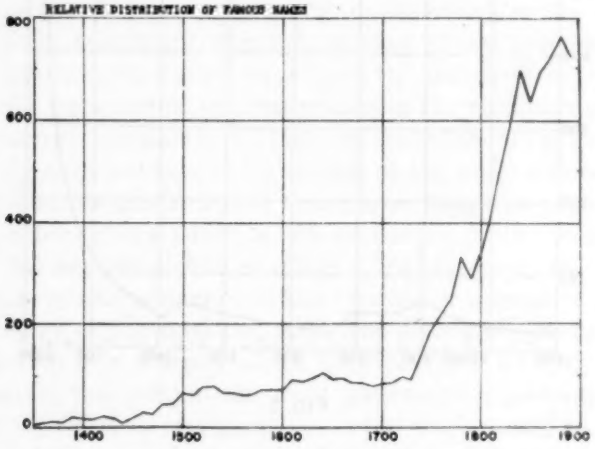

FIG. 2

the work of Jules Beloch and other scholars, the graph portrays the growth, and at times decline, of population in Europe since the year 300 B.C. Crude though the evidence for much of this may be, it represents at least schematically the general pattern of the fluctuating fortunes of human society for more than twenty-two centuries. The great plagues that struck the ancient world, the pestilence which raged during the reign of Justinian in the sixth century, and the Black Death of the fourteenth century, are represented in the substantial dips in the wavering line of the chart. If any one should doubt too seriously the general picture thus presented of the vicissitudes of population growth in Europe he has a simple test in his own library. Let such a skeptic chart century by century the number of historical characters listed in the back of his dictionary. Let him then assume that the number of great names is roughly proportional

to the number in the population which produces them. And lo! he will find that he has produced in miniature an approximation to the curve of population that has been given. Such a representation has been made in Figure 2.

The reason for dwelling upon these matters in a discussion of power is to show the terrifying reality of the economic problem presented by the growth of population during the last three centuries and a half. Suddenly and without apparent reason the population of Europe began to increase near the beginning of the fifteenth century. By 1700 the rate of growth had become a noteworthy matter and in the subsequent years developed into a phenomenon such as the world had never seen before. From a population estimated at around 87 millions in 1600 the nations of Europe had increased to the astounding total of 535 millions in 1940, a six-fold growth in the space of 340 years. No history can portray more vividly the causes of the incessant tumults of Europe than this simple fact. For the people of each nation press with ever increasing force against the boundaries of their neighbors and seek to escape the fate described by the Malthian theory that populations will ultimately outgrow their food supply. No league of nations and no court of international law can alter in the slightest degree the brutal facts presented by this picture of population growth.

With this astonishing growth of population before us, we turn to another and brighter side of the picture. For the increase in population has been attended by a concomitant increase in standards of living. In order to show this by comparing the wages of one period with another it will be necessary to employ the concept of a wheat *numéraire*, or currency, since the ratio of gold to silver has fluctuated widely in recent times and monies based upon these metals have had an even greater variation. For example, in the United States since 1925 the money value of a bushel of wheat has fluctuated from 33 cents to over $2.00; in Rome from the time of Augustus Caesar to the time of Diocletian the price of a bushel of wheat varied from about 4 denarii to more than 400. This fluctuation was not occasioned by crop failures or over-production, but was inherent in the changing value of money. This is readily seen from the fact that the ratio of the price of wheat to the price of other commodities has remained through long periods of time a reasonably stable quantity. Hence it is possible to approximate the economic value of real wages by reducing these to their buying power in terms of

wheat. These wheat wages in their turn serve as an approximate measure of the general standard of living of most people whose incomes are never far removed from that set by the wages of labor.

Returning to the problem of comparing standards of wages in different periods of time, let us consider a few figures. In 1600 the daily wages of the laboring man in England would purchase 16 pounds of wheat per day, a figure little better than that which prevailed throughout the Roman world, which, though con-

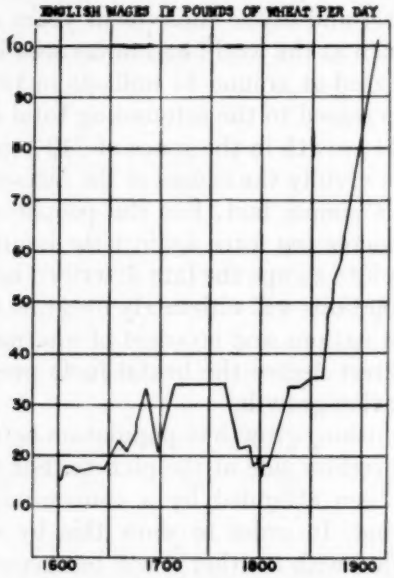

FIG. 3

spicuous for its laws and its humanistic culture, contributed little to the utilization of energy. During the first quarter of the nineteenth century this purchasing power of labor had doubled. By 1882 it had doubled again, and in 1914, at the beginning of the first world war, the price of a day's work had attained the level of 100 pounds of wheat. But the end had not been reached, for during the quarter of a century that spans the two world wars the price of labor increased at least 150 per cent and stood in 1940 at 250 pounds of wheat per day. The comparisons which we have made are graphically represented in Figure 3.

We who survey the past from the dizzy height of well-being that has prevailed in our own times can scarcely credit the testi-

mony of ancient documents. The budget of Cato's slave has come down to us from about 200 B.C. and provides a clear picture of standards of living that prevailed in earlier times. With wheat quoted at $2\frac{1}{2}$ denarii per bushel, the food and clothing of this slave cost annually 78 denarii, or the equivalent of 31 bushels of wheat. In the famous edict of Diocletian (301 A.D.), which placed a ceiling upon all the prices in the Roman empire and decreed death for those who operated black markets anywhere, the price of common labor was set at 28 bushels of wheat per year plus maintenance, while stone masons received about twice as much. If we estimate 300 working days in the year these figures show that common labor was purchased for about 10 pounds of wheat per day and the more skilled occupations

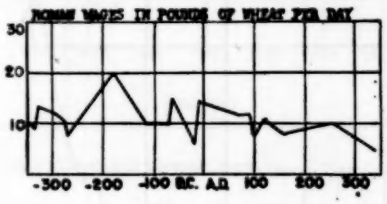

FIG. 4

brought not more than twice this amount. The school teacher who was fortunate enough to have a class of 30 pupils, received 45 bushels of wheat per year, or 9 pounds per working day, while even the highly paid professor of literature and geometry received only four times this amount, or 36 pounds per each day that he taught. The fluctuations in real wages in the Roman period is graphically portrayed in Figure 4.

It is a long hill that we have climbed and it would be well to pause a moment and look down the slope. To some these figures may seem fantastic and even lack the aspect of truth. Let those who take this skeptic's view consider the wages which have prevailed in recent years in the Orient. According to a detailed budget study made in 1928 the standards of living which prevailed in modern Shanghai are still those which we have found in ancient Rome and in England of the 16th century. The millworkers in this thriving doorway into China received a per capita annual wage equal to 32 bushels of wheat, almost exactly that given by Cato to his slave, and the mill foremen slightly more than twice this amount. If we reduce these figures to daily wages we see that common labor was purchased for 9.5 pounds

of wheat per day and the more skilled workman received an equivalent of 20.5 pounds per day. Thus we see that the twenty-one centuries intervening between the two budgets have not brought amelioration to the poor in those economic states that have failed to make use of scientific methods to increase their use of power.

Now the most conspicuous difference between the ancient economic system and our own is found in the steady development of science and engineering. This development was slow during the 17th and 18th centuries, but it has increased in a spectacular manner during the latter half of the 19th century

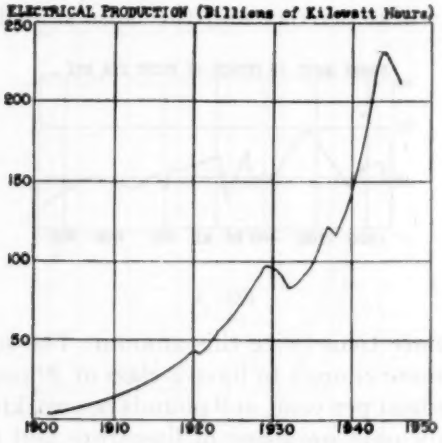

FIG. 5

and during the present century. The rapidity of this growth of power is illustrated by Figure 5 which shows the increase in electrical production in billions of kilowatt hours since 1903. In the nineteenth century the development of steam power was similarly remarkable. But the importance for society as a whole is not actually the growth of power, but the industrial development that accompanied it, since it is the fruit of this development that determines the standard of living which prevails. In Figure 6 is shown the index of industrial production from 1884 to 1940. The irregularities in the index are measures of the influence of those factors which are generally spoken of as the business cycle. Unfortunately these factors are subject to large perturbations, as is shown from the too frequent depressions that have halted temporarily the progress of production.

The growth of power, which has been greater than the growth of population in the last century, is the obvious cause of the increase in standards of living and in the real wages paid to labor. With this growth has come more leisure and this leisure in turn has provided opportunities for an increasing develop-

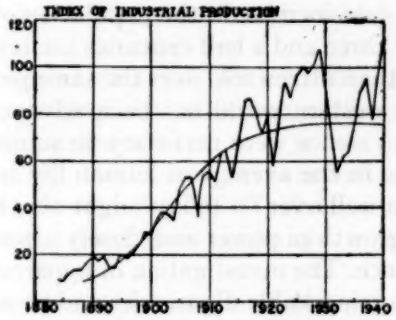

FIG. 6

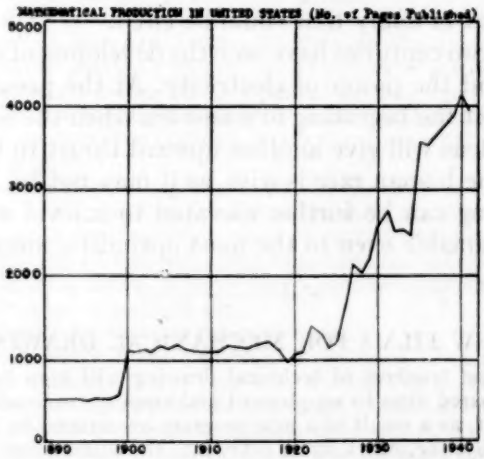

FIG. 7

ment of science and engineering. How great this has been can be estimated at least approximately from the graph in Figure 7, which shows the increase in mathematical research in the United States during the last half century. The data for the figure are derived from the number of pages published annually by the leading mathematical research journals of the country. There

is every reason to believe that a similar study of other scientific disciplines would show an identical increase.

5. Concluding Remarks

We are thus led to the inescapable conclusion that the growth of power has been at the basis of our rising standards of living. In spite of a six-fold increase in the population of Europe over a period of nearly three and a half centuries the level of wages has increased more than fifteen fold over the same period, and living throughout the western world has been advanced correspondingly. If other evidence were necessary to support this conclusion the increase in the average of human life from 25 years in Roman times to well over 60 today might also be adduced.

Back of this growth of power and closely associated with it is the work of science. The investigation of apparently small problems have led to remarkable discoveries and these in turn to the development of vast industries. Faraday's curiosity as to the relationship between magnetic and electric forces and Einstein's musings on the relationship between space and time are but two examples out of many that could be cited.

The last two centuries have seen the development of the power of steam and the power of electricity. At the present time we seem to be at the beginning of a new era when the secrets of the atomic nucleus will give another upward thrust to the curve of power. If the human race is wise, as it may not be, then standards of living can be further elevated to a level which would seem unattainable even to the most optimistic imagination.

NEW FILMS FOR MECHANICAL DRAWING

Students and teachers of technical drawing will soon be able to use specially prepared films to supplement and amplify two leading textbooks on the subject, as a result of a new program announced by McGraw-Hill Book Company, Inc. Marking its entry into the educational film field, the Company has started production of two series of McGraw-Hill Text-Films on the principles and techniques of Mechanical and Engineering Drawing, each consisting of seven 16 mm. sound motion pictures and a like number of coordinated silent filmstrips. They will be ready for distribution next Spring.

One series of Text-Films will correlate with French's *Engineering Drawing*, a textbook widely used for three decades in colleges and technical institutes. The other series of Text-Films will correlate with the high school text, French and Svenson's *Mechanical Drawing*. Instructors' manuals will also be provided, with suggestions on making effective, integrated use of these teaching materials.

SUGGESTIONS FOR TEACHING WEATHER IN THE ELEMENTARY GRADES

GARNET TODD
Harrison School, East Chicago, Indiana

With the seasonal change into winter, the elementary science program easily moves from the natural sciences to the physical sciences.

The weather is the subject of almost everyday conversation and since it is a part of everyday living, its phases are easily taught during the winter weeks.

We usually refer to the kind of day it is by saying "It is cold today" or "It is warmer today" or "It is damp today." By "it" we mean the air is cold the air is warmer or the air is full of moisture today.

In order to teach children that even though air cannot be seen it does not take up space and it does have pressure, the teacher may show, through simple experiments, the truth of such facts.

1. Inhale air to expand the lungs.
2. Exhale into a balloon to expand the rubber.
3. Put a rubber tube inside of a milk bottle or flask and turn it upside side down in a large pan of water. Suck air out of bottle and the water goes up into it; blow air into the bottle and water goes down. The air taken out of the bottle leaves a partial vacuum and air pushes the water into the bottle. Air blown into the bottle pushes the water down. (If an aquarium is handy, it is easier to see what happens than in a pan of water.)
4. Siphon water from an aquarium to show the effect of air pressure.
5. Drink milk or water through a straw to show the same principle.
6. Burn paper in a milk bottle to create a partial vacuum. Place peeled hard boiled egg on top. Air pushes to get into the vacuum and pushes the egg into the bottle. (Cite mother's vacuum cleaner as example of everyday usage of pushing air.)
7. Use a pipette to show air takes up space.
8. Put a little water in the bottom of a test tube. Cork the top so no air escapes. Hold the test tube over a candle or burner. When the water becomes hot and the air and steam expand, the cork is forced out. (Cite pressure cooker and safety devices.)
9. Heat water to show evaporation and that air takes up moisture.
10. Hold cold mirror over boiling water to show condensation.
11. Draw diagram of water evaporating into warm air from lakes, streams, puddles, plants, etc. and as cold air hits warm air, the evaporated water condenses into clouds or drops of water and falls back to earth as rain.
12. Put a plant under a bell jar to show that leaves give off water into the air.
13. Show that wind is moving air by using a fan or making paper pinwheels to use out of doors.
14. Make a simple vane. Place a lead pencil point down into a small hole made in the top of a cigar box. Put a test tube upside down over

the pencil. Attach to the top of the test tube a cardboard arrow and fasten with a rubber band.

On one side of the box place an "N" for north. On the right side of the "N" will be east—on the left, west—and on the opposite side will be south. When the weather vane is taken out of doors away from buildings, the arrow will turn toward the direction from which the wind is coming.

15. Take thermometers to various places to see differences in the temperature of air.
16. Make a large cardboard thermometer with red slide to move up and down and have individual children keep temperatures at proper degree. This is good help in learning to read thermometers accurately.
17. Cut out weather forecasts from newspapers and learn what is meant by symbols—U. S. Weather Bureau symbols—

○ clear	® rain	▲ hail
◐ partly cloudy	Ⓢ snow	△ sleet
● cloudy	Ⓜ report missing	thunderstorm
	storm warning	

Children may make weather chart of each day using symbols.

18. Make weather flags using a red one as a temperature flag—a blue and white flag for rain or snow—and a white flag for fair.

Each day a different child, as "weatherman," posts the flags. One method found to be easily understood by children is to place the red flag above either of the other two to denote warmer, and to place below either of the other flags to denote colder. No red flag would mean no change in temperature.

As weather interest increases and workings of the thermometer and air pressure become simpler, try to forecast weather day by day keeping a check as to why predictions might fail or change.

Incidental with the study of weather are such things as making snowflake patterns of various sizes, being sure all are six pointed; studying seasonal changes; noting the effect of weather on various industrial or agricultural groups of people; the effect of types of weather on animals and plant life

The study of sun and heat may work into this time of year as well as the study of magnetism in using compasses while telling the direction of wind.

Each day's learning of scientific knowledge goes from the experienced "known" to the unknown as a pattern that lends to learning an excitement and variation that never leaves two classes taught in the same way.

Paper disks for magnetic phonograph records are coated with an iron-oxide emulsion, and can be re-used many times if wiped off with a magnet. A disk carrying a conversation can be mailed and then placed back to the receiver in an identical recording-reproducing machine.

THE INDIANA CONSERVATION EDUCATION CAMP FOR TEACHERS*

HOWARD H. MICHAUD
Purdue University, Lafayette, Indiana

"We have writing and teaching, science and power; we have tamed the beasts and schooled the lightning—but we have still to tame ourselves." H. G. Wells.

This theme pertains to power and products, especially in their relation to intelligent use by man to maintain the peace of the world. The obligation for peace rests with the character of man whose past history in the use of scientific tools has added considerably to the havoc wrought upon earth. This is none the less true of man's use of the natural resources of the land.

We look to science for better health, more jobs, higher standards of living, and an increase of security for the individual. Yet, we know that man has endeavored to apply the King Midas touch rather than attempt to live in harmony with nature and her patient ways. We are all aware of the problems of conservation of soil, water, plants, and wildlife. Our main efforts must be directed toward a solution of these problems if our country is to survive.

Our greatest hope lies in education. It is the responsibility of teachers to inculcate in the minds of youth a respect for our natural resources and to bring about a change in the traditional habits of thinking that resources are inexhaustible. A philosophy of abundance has prevailed, in peace and in war, that has resulted in indifference to the problem of shortages confronting the nation. Even those closest to the soil, the landowners, have followed custom and bad land practices, rather than adopt new ideas that help protect the land. Conservation education must begin with our children before they become steeped in the habits of their progenitors, if this country is to maintain the standards for which we strive.

Education in conservation for teachers has made notable progress in the past decade. Many new conservation courses are appearing in the college catalogues. A four year curriculum with a major in conservation is now available at the University of Wisconsin and at State Teachers College of the same state. County workshops for teachers are in operation in Illinois and Ohio to

* Delivered before the Biology Section of the Central Association of Science and Mathematics Teachers, November 29, 1946.

study the problems of resource use. Out of door conservation courses were conducted last summer in a dozen states east of the Mississippi.

Indiana has instituted a training program for teachers in service and for prospective teachers. Three courses that can be taken in sequence provide the opportunity for training that will aid in teaching conservation more effectively. They are (1) General Conservation, (2) Field Course in Conservation and, (3) Teaching Conservation. These courses are administered by the Department of Forestry of Purdue University.

The first course is designed to show the history of waste and exploitation in our nation and to develop an awareness of the necessity of wise resource use. The second is given at the Conservation Education Camp at Versailles State Park, Versailles, Indiana. The third course is intended to enable a teacher to transpose conservation knowledge into a functional program for the schools.

It is the Conservation Education Camp that is herewith more completely described as a method for presenting, most effectively, the problems in teaching conservation. Last summer's camp represented the first organized effort in Indiana in this field of training. Although substantial success was attained there are areas that experience will help to improve.

The Indiana camp was jointly sponsored by the Indiana Department of Conservation, the State Office of Public Instruction, and Purdue University. A permanent teaching staff from Purdue and several visiting instructors from other state colleges helped conduct classes. Six semester-hours of University credit were granted for the five and one-half weeks required for the completion of the course.

Versailles State Park in southeastern Indiana is a scenic area of varied terrain, rich in geological formations of the Ordovician series, traversed by streams and clothed with forests of second-growth timber. Most of the five thousand acres was once employed as agricultural land that, because of improper use, became abandoned and returned to nature. About two thousand five hundred acres have been used as a wildlife habitat area by the Indiana Department of Conservation in cooperation with the Federal Aid to Wildlife Restoration. Conservation practices in progress make the park a very suitable location for the study of the ecological principles that should be understood by every teacher.

The camp buildings were originally one of the most elaborate of the CCC camps in Indiana. Through the help of the Indiana Division of State Parks the buildings were modified and equipped to be used as a co-educational group camp. The buildings include a large rustic mess hall of wood and stone construction, a recreation and classroom building, a shower house with modern rest room facilities, and three room cabins for living quarters. The physical comforts of students were excellently provided in housing, food, and sanitary accommodations.

The methods of study employed were primarily designed to furnish the teacher the proper tools and knowledge to teach conservation out of doors. The interrelations of soils, plants, water, and animals were emphasized throughout the plan. During the first two weeks the study of soils was particularly stressed. Along with this, the identification of plants and animals was considered to be important.

An understanding of the chemical and physical properties of soils was regarded as essential to the knowledge of conservation relationships. Students who admittedly had no previous understanding of soil profiles, pH values, soil types, and land use classification were able within a short time to perform many interesting experiments in the study of soils. Soil testing kits were used to determine the fertility levels of soils, and to test plants for nitrates, phosphates, and potassium. Soil samples from the different horizons of a soil profile were prepared for demonstrations. Farms and forests were visited to gain practical information for wise land use.

Because of the close relation of plants to soils and the affinity of animals to plants there was great emphasis placed upon the identification of plant and animal species. A full appreciation of the principles of conservation is inconceivable without some ability to recognize species. Simple keys were used at first to identify trees and shrubs until students learned to master the mechanics of taxonomic sorting. Correct methods of collecting, mounting, and labelling herbarium collections were explained and students were required to present suitable collections at the end of the work. Quadrats and other sampling procedures were employed as basic to a study of the ecological principles of land use.

Early morning bird hikes were conducted two mornings of each week of camp. Insects and other invertebrates were collected. Some of the vertebrates like toads, salamanders, snakes,

fishes, and mammals were caught. These animals were assembled in the laboratory, classified, and identified to help develop, as completely as possible, the idea of biotic associations.

The rudiments of simple forestry were studied. Timber cruising, by use of the Biltmore stick and diameter tape, was recorded by the ten point tally system. Climax, sub-climax, and transition forests were examined, as well as artificial and natural regeneration, to give concrete meaning to the development of landscapes.

The culmination of teaching methods and studies in conservation were consummated by the use of plot studies. Two adjoining one acre plots, 600 feet by 75 feet, were established. The narrow end of each plot faced a sizeable creek in the park. Each plot embraced four habitat areas, with elevations beginning at the creek level to 65 feet of height at the summit of the acre. The four habitats consisted of (1) a sycamore and box-elder tree association along the creek, (2) a low bottomland of teasle, ironweed, sedges, grasses, etc., (3) an oak-hickory hillside forest and, (4) a hilltop plateau of shrubs, weeds, and encroaching tree seedlings.

The students were divided into two groups. Each group was assigned a captain who divided the work of collecting all the necessary data to assemble a total picture of the area. This included a scaled map of the plot showing vegetation types, contours at each five foot level, pH values by elevation, and location of sampling quadrats for plant and animal counts. A homemade plane table and alidade, consisting of a straight-edged ruler and insect pins, served to map the plots. A carpenter's level mounted on a five foot two by four was used to establish the contour lines. A complete timber cruise was made of all standing timber of more than one inch diameter size.

The completed written account and data provided an original study, albeit somewhat crude, which served to crystallize all the practical conservation methods introduced in the course. Because of the work involved, not all of the students fully appreciated the value of their labors. It is believed that the benefits from such work will have far more enduring effects than a mere discussion of conservation problems can ever produce.

Finally, an attempt was made to focalize the study of conservation and to translate it into the needs of the individual teacher. Each teacher was asked to present a curriculum outline either in science, geography, biology, or social science, depending upon

the area of the teacher's chief concern. Within this outline were to be placed all of the conservation concepts that could be justifiably handled in the chosen field. Separate, simple conservation topics or units were then to be worked out to bring the story directly to the classroom. Since teachers represented both the elementary and high school field, it was necessary to require the teacher to translate the knowledge gained at the Conservation Education Camp to a functional program for her own classroom needs.

In the writer's opinion, all conservation workshops should require more than just a series of lectures and classroom discussions. A week of conservation pep-talks by experts may have as little educational influence as evangelism without the profounder aspects of Christianity. Conservation must be brought to the community as a program of action and not just a show of fiddling while America burns.

COLLEGE ENROLLMENTS TOP PREVIOUS RECORD BY FIFTY PERCENT

More than 2 million students, a fifty per cent increase over the previous peak enrollment, are now attending the 1749 colleges and universities of the United States, it was reported by Dr. Francis G. Cornell, Chief of the Research and Statistical Service of the United States Office of Education Federal Security Agency.

The total of 2,062,000, based on an October 15 survey by the Office of Education, was compared with the previous October peak enrollment of 1,360,000 reported in the pre-war 1939–40. The 1946 Office of Educati n survey covered those students attending classes or lectures conducted by the regular colleges and schools but did not include students enrolled in extension or correspondence courses.

Dr. John Dale Russell, Director of the Higher Education Division of the Office of Education, in commenting on the record enrollment stated: "The present student load, which is more than double the 950,000 total of last year, has heavily taxed the resources of almost all higher educational institutions in providing adequate staff, housing, and classroom facilities. Every effort has been turned to supplying the demand for admission to college, particularly on behalf of veterans entitled to educational benefits under Public Laws 346 and 16."

In 1945 there were fewer than 50,000 veterans enrolled in higher educational institutions. This year there are 1,073,000 veterans enrolled, or approximately one-half of the present total number of students. Almost half of all students and more than half of the veterans are enrolled in the 131 larger institutions.

According to the survey, more women (667,000) are attending college this year than ever before, even though the percentage of the total has dropped markedly, due largely to the phenomenal increase of men veterans. This year, women students constitute 32 percent of the total as contrasted with 61 percent in 1945, 63 percent in 1943, and 39 percent in 1941.

A PLAN FOR LABORATORY ACTIVITIES IN GENERAL SCIENCE*

IRA C. DAVIS
University of Wisconsin, Madison, Wisconsin

Many teachers fail to make the best possible uses of the laboratory in general science. Too much emphasis is placed on the study of the facts and principles given in textbooks without bringing these facts and principles within the experiences of boys and girls. Science deals with methods, materials, processes, skills, techniques, observations and experiences. It also provides outlets and opportunities for the original and creative abilities of pupils through laboratory teaching.

There are five types of laboratory activities which need to be planned for pupils. These are not to be compared with, or to be considered as like the formal laboratory procedures so often used in science classes. In the first type, emphasis is placed on the getting of information through the activities planned by the teacher. This type includes skills, techniques, methods and observations as well as the learning of facts and principles. It also provides for originality and creative ability through the follow-up activities suggested.

In the second type of activity, pupils are given "things to do." Results occur. Pupils raise questions about the results and a problem is developed. The solution for the problem is developed by the pupils as a group. This is the way problems are discovered outside of school.

The controlled experiment is the third type of laboratory activity. In this type pupils learn the meaning of controls and variables. They also learn how to plan a controlled experiment and then perform the activities as planned. The controlled experiment is one of the greatest contributions science has made to clear thinking. Pupils should learn how to experiment in this type of activity.

In the fourth type of laboratory activity, emphasis is placed on the need of verification of things presented in textbooks or things read in newspapers or magazines. The problem here is to reduce to laboratory procedures the types of activities which pupils need to encourage them to believe what they have read or heard.

* Read before the General Science Section of the Central Association of Science and Mathematics Teachers at Detroit, November 29, 1946.

The fifth type of laboratory activity is built around problems and projects. Here pupils usually plan the procedures for solving a problem such as the construction of some new piece of apparatus, the laboratory study of some local problem, or developing a plan for the demonstration of some scientific or commercial process. Here the emphasis is on doing things and making things and giving pupils opportunities for originality and creative ability. It also gives them valuable experiences in using tools and materials.

If we were to train a person to become a good musician we would expect him to become skilled in playing some instrument. It would not be enough to study music from a book or learn how to read music. These are necessary but they do not make a good musician. The same thing is true with training a person to become a mechanic. Certainly we would expect him to know how to use tools and machines. Why do we think we can make boys and girls good scientists without having them learn how to use the great tools and inventions our scientists have made and without learning how these great inventions were made possible?

Teachers are justified in asking how can these types of laboratory activities be provided under the present conditions in our schools. True, many schools are not equipped to provide these activities, but there is no reason why they cannot be equipped to do so. Certainly it does not cost more to equip a good science laboratory than it does a good home economics room, an industrial arts room, a musical organization using musical instruments, an art room or a gymnasium. Further, the cost of supplies need not be greater than any of the subject areas just mentioned. Financial considerations then are not the cause of poorly equipped laboratories. We do not have them because teachers have not demanded them and because it is easier to teach science without them.

What is needed for a good laboratory for general science? First of all, we need good laboratory tables, a demonstration desk, storage cases, running water and two or three sinks. The tables should be equipped with gas and some supply of electrical energy, preferably 110 to 120 volt A.C. current. The demonstration desk should be supplied with running water, gas and electricity. The room should have dark curtains so all forms of visual aids can be used. A work bench is also very desirable.

The apparatus and materials should be selected on the basis of need and frequency of use. The cost is not excessive.

No doubt you are now asking what kind of activities are to be performed in the laboratory. The most fruitful and valuable source for these activities is to make a list of the world's most important and elemental inventive discoveries. If you were asked to select forty of these great inventive discoveries, what forty would you select? There is not anything sacred about saying forty but if you could list forty you would have all of the activities you could use. I will list forty. They are not necessarily given in historical sequence or in the order of relative importance, but they all play a very important part in our everyday living. Here is the list:

Mirror
Plants grow from seeds
Fire and its control
Pottery ware, cooking utensils
Oil lamps—burning fuels to produce light
Balance—weighing
Ruler—measurement
Bow and arrow—sling shot
Pendulum—keeping time—clocks
Plants get raw materials for growth from the air and soil. Photosynthesis
Writing and printing—preservation and dissemination of knowledge. Alphabet
Lever—pulley, wheel and axle
Inclined plane—wedge—screw } tools
Lens
Compass—exploration—magnetism
Wheel—circular motion—transportation
Boat—water transportation
Plow—tools for cultivating the soil
Steam engine—industrial age
Microscope—Magnifications
Telescope—Astronomy—optical instruments
Prism—color
Stove—heating and shelter
Air pump—bicycle pump
Barometer—weather predictions
Thermometer—heat measurement
Blast furnace—blast lamp—blow-pipe, manufacture of iron and steel
Musical instruments, sounds can be produced by setting matter in vibration.

So far I have listed about 25 great inventive discoveries. We usually think of the 19th and 20th centuries as being the period in which most of our inventions have been made, but all of these were discovered before this period, many of them more than two thousand years ago. Many of our scientific discoveries are very old.

Now to proceed with the more recent discoveries.

Chemical cell—storage cell—using chemical action to produce an electric current
Electromagnet—rapid communication
Electroplating—electrochemical industries
Dynamo—electrical energy
Electric motor—use of electrical energy for motion
Germ theory of disease—bacteria—yeasts—molds
Cell structure of living things
Canning of foods—food preservation
Telegraph—Communication
Telephone, radio—rapid communication
Bunsen burner—mixing air with a fuel before it is burned
Photography—pictures can be made by chemical action—camera
Internal combustion engine
Phonograph—reproduction and preservation of sounds
Incandescent light—fluorescent lighting, arc light
Vacuum tube—uses in radio, telegraphy, etc.
Photoelectric cell, television
Atomic fission.

This completes my list of forty-five great inventive discoveries. An inventive discovery is a type of discovery which can be made the basis of laboratory activity in which pupils learn how to use these great discoveries and also learn to appreciate their importance in our daily living. Possibly five of these discoveries could not easily be reduced to laboratory study at the junior high school level. This leaves forty great inventive discoveries that could be reduced to a laboratory procedure at this level. All of them have many social implications which need to be emphasized. Some of you may say I have omitted many discoveries of a biological nature such as all living things come from living things; Mendelian traits of inheritance, nutritional value of foods, or the life cycle of insects. They are all very important but they are not easily reduced to valuable laboratory activities and can better be taught in some other subject areas. Further, many of them require a much longer period of laboratory activity than do the activities in physical science with a consequent loss in continuous interest.

Laboratory activities can be performed by pupils of varying abilities. Investigations appear to prove that poor students are as good observers as good students—both groups have equally good eyes. Many teachers confuse results with reasons for the results. Laboratory activities and demonstrations give results but never the reason for the results. Why things happen are explained by reasoning. The best students do the best reasoning, but it is not necessary for all pupils to know the why of everything. We do not know how light passes through glass but that

does not stop us from using glass. Would you think of denying pupils the opportunity of using a microscope or telescope because they could not explain how the images were formed? If you insisted on that, then more than one-half of our teachers would never be permitted to use a microscope or telescope. As another illustration, I might place equal volumes of water in two different sized containers and discover that the water evaporated more rapidly from the large container. But that does not tell me why it evaporated more rapidly from the large container. To explain that thoroughly, a pupil would need to know something about molecules, the molecular theory, the kinetic theory, humidity, air currents, temperature and energy changes. How long has it taken the human race to learn that evaporation could be used as a cooling process for refrigeration? But we expect pupils to learn the same thing from one simple experiment.

I am not attempting to minimize the desirability of having pupils acquire thorough understanding, but I do want to make it clear that while laboratory activities and demonstrations do give us answers for things that happen, they never give us the reasons for these answers. Further, we ought to make it clear to pupils that if we use theories to explain why some things happen as they do, it is an admission on our part we may not have the complete reason for the answer.

For further explanation of what I mean by laboratory activities, I will give illustrations of two types of activities not usually provided for in our present methods of teaching. The first type of activity is what I prefer to call a problem discovery activity. In this activity pupils are "*given things to do*" before any class discussion has taken place. In this activity pupils will be asked to attach a candle to a cardboard four inches square by using the dripping wax from the lighted candle. Here a lesson in safety in using a flame may be demonstrated. Each pupil now holds the candle flame near (a) beaker filled with water, (b) piece of plate glass, (c) at different distances from the glass in the window, (d) plastered wall, (e) blackboard, (f) mirror, (g) translucent glass—glass rough on one side and smooth on the other.

Pupils will be encouraged to make as complete observations as possible and record briefly the observations made.

A discussion of results occurs and a problem is raised. What question do you think the pupils will ask? Why was an image (picture) of the flame formed with some surfaces and not the others? Here it may be suggested that pupils feel the different

surfaces and observe similarities and differences. They will observe some surfaces are smooth and others are rough, some are dark and others are light colored. Some are transparent, others are opaque. They may even say some are translucent. They will now conclude that all of the smooth surfaces formed images while the rough surfaces did not.

Now to test their ability to apply results. Direct the pupils to stand in front of the different surfaces where they can see themselves. If this is not possible, ask them to place the candle near the surface in the room where the most distinct image will be formed. There should be some such surface in the room which has not been used.

This is not the end of the problem, it is just the beginning. Now pupils want to learn something about the image. In planning the following activities the teacher wants them to learn that the image is erect, it is reversed, and the image appears to be behind the reflecting surface. Some pupils may have observed these characteristics of the image. Next the pupils will hold the candles near a window pane, and bring pencils toward the candles from the right. Then move the candles back and forth in front of the glass, then above a beaker of water at one side while they look into the water from the opposite side.

It is not easy for pupils to understand what is meant when we say the image is reversed (backwards). Next have them hold a mirror in front of their eyes with one hand and place a finger of the other hand on the eye that appears on the left in the mirror. Then have them write their names on sheets of paper and hold them parallel with the mirror and observe that they see in the mirror. Then have them write their names so they appear to be correctly written as observed in the mirror. It would be helpful here to have one line of type as set for printing. If this is not enough, have one pupil stand in front of a good sized mirror. Then have him tell a pupil to stand behind the mirror where his image appears to be and in the same apparent position. Then remove the mirror and have them shake hands.

So far the teacher has developed inductively how images are formed and the characteristics of the image. A vocabulary needs to be developed through the use of the textbook. Word study is very important in science.

In this laboratory activity the emphasis has been placed on the what and how of science—not the why! In all of the activities so far the pupils have stood directly in front of the sur-

faces. Now place some object to the right of a mirror (45°) and have some one locate the position where the image of the first object may be observed. Change the position of the first object two or three times. Next place a pencil at an angle with a mirror. Then place a second pencil so it appears to be in a straight line with the first pencil as observed in the mirror. Pupils will soon learn something akin to saying the angle of reflection equals the angle of incidence. Next have them arrange their mirrors to reflect sunlight to some spot on a side wall and then to the ceiling. Here is their opportunity to apply what they have learned.

The pupils are now ready to take up double reflection by placing a candle between two mirrors which are parallel to each other. Then arrange two mirrors so a pupil can see the back of his head, as is done in some stores. A simple periscope can also be made.

If the room can be darkened and the teacher has a flashlight or lantern that will project parallel rays of light, some worthwhile demonstrations may be performed. Hold the lantern so the rays of light will strike the following objects at the angle which will reflect the light to the ceiling. First use a mirror, then plate glass, translucent glass (both sides) white, black and blue paper, surface of water in a dish, then shake the dish. These demonstrations will help pupils learn which surfaces reflect light which diffuse light, and which absorb light. Then the problem of glare can easily be demonstrated.

Now the teacher is ready to begin the development of real images with the use of concave mirrors. This may be done by a few simple demonstrations. Many more activities may be planned if several curved mirrors are available. Then to reflectors on lamps, automobile headlights, beacon lights, the new train lights, and the reflecting telescope. The activities with curved mirrors in forming different kinds of images will be an introduction to the study of images with lenses which will come later.

Out of all of these activities many questions will be raised by pupils. Many of these questions can become the basis for real problems and projects. They may be solved by pupils individually or in small groups.

The controlled experiment is the second type of activity that needs more emphasis. It is not difficult to plan demonstrations so several factors may be introduced into an experiment. In evaporation a teacher may use different sized dishes, different

liquids, different temperatures and with varying amounts of air currents. If carefully planned, the results will be contradictory as far as any one factor is concerned. As a result, pupils will observe that the rate of evaporation may be affected by surface area, temperature, winds or the nature of the liquid. Here we have four possible variable factors. The class may be divided into four groups with each group being responsible for discovering the effect of one factor on the rate of evaporation. Each group will need to control the other factors. After each group has completed its plans, they are read to the class. Then all of the groups will need to plan the controls for all the experiments.

If A is the only factor that is allowed to vary in an experiment, then factor A must produce the result, if there is a result. Here the chance of knowing what factor produced the result is 1 in 1, or certainty. It is simplicity itself. If factors A and B are allowed to vary at the same time, then the results, if there are any, may be produced by A alone, by B alone or by the combination of A with B. Here the chance of knowing what factor or factors produced the result is one in three. This is very little better than guessing, if any better. If three factors are allowed to vary at the same time, the chance of knowing what factor, or combinations of factors, produced the results is one in seven and for four factors it is one in fifteen.

Pupils can learn to plan a controlled experiment without any great difficulty. There is marked improvement in the second experiment and still more improvement in the third. It is not necessary to perform more than three or four a year to have pupils learn how to experiment.

Can pupils detect faulty experimentation as reported in advertisements and over the radio? If you do not think they can, then bring in copies of advertisements in which some photograph, diagram or description tells how an experiment was performed. The lack of carefully controlled experimentation is easily detected. Dishonest advertisers know people believe in the results of experiments. The descriptions of their so-called experiments are planned to deceive people rather than give the truth.

I believe most of you are familiar with the other types of laboratory activities which have been suggested. All worthwhile laboratory activities must be carefully planned or initiated so that pupils will have direct contact with materials and will learn how to use the most important inventive discoveries the human

race has developed. These are the great inventions they use every day. These are the things that make modern living possible. We must then do everything possible to see that pupils are given the opportunity to study science in well equipped laboratories, and with teachers who are always conscious of the great possibilities laboratories have to offer.

THE QUIZ SECTION

JULIUS SUMNER MILLER
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1. Rodents are gnawing animals. (T or F)
2. If water is boiling *gently* it is just as hot as when boiling *vigorously*. (T or F)
3. Neon forms no known compounds. (T or F)
4. Who said: "If I have seen farther than other men, it is because I have stood on the shoulders of giants"?
5. *All* the planets and asteroids revolve around the sun in the *same* direction. (T or F)
6. White sand (SiO_2) mixed with limestone ($CaCO_3$) and sodium carbonate (Na_2CO_3) and highly heated yields what common substance?
7. The eye accommodates for distance by changing the curvature of the lens. (T or F)
8. The *shape* of the Big Dipper is constant and fixed. (T or F)
9. Neutrons can be accelerated by an electrostatic field. (T or F)
10. The primary bow (of the rainbow) is *red* on its *outer* side. (T or F)
11. Pi does not satisfy *any* polynomial equation with integral coefficients. (T or F)
12. The logarithm of 1 to any base is zero. (T or F)
13. What is the coccygeal region?

ANSWERS TO THE QUIZ SECTION

1. T; 2. T; 3. T; 4. Newton; 5. T; 6. Glass; 7. T; 8. F; 9. F; 10. T; 11. T; 12. T; 13. Man's flesh-covered tail-remnant.

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INTEGRAL SOLUTIONS OF $x^2+y^2+z^2=r^2$

RALPH HOYT BACON*
Fairchild Camera and Instrument Corporation, Jamaica, New York

$$x^2+y^2+z^2=r^2.$$

A table of integral solutions of this equation may be useful to those who like to devise problems for students. A few words about methods of obtaining these solutions may be of interest to others, also.

In Chapter VII, Volume II, of his History of the Theory of Numbers, Dickson[1] mentions a dozen or so of these methods—some of them devised by great mathematicians. The usual method is to find an identity containing four terms such that the sum of the squares of three of the terms is equal to the square of the fourth.

THE IDENTITIES OF EULER AND OF GILL

Perhaps the best known of these identities is the one introduced by Euler in 1779:

$$[(p^2+1)(q^2-1)]^2+[2q(p^2-1)]^2+[4pq]^2=[(p^2+1)(q^2+1)]^2. \quad (1)$$

This is but a special case of a more general identity:

$$[(p^2+m^2)(q^2-n^2)]^2+[2nq(p^2-m^2)]^2+[4mnpq]^2 = [(p^2+m^2)(q^2+n^2)]^2 \quad (2)$$

where

$$\begin{aligned} x&=(p^2+m^2)(q^2-n^2)\\ y&=2nq(p^2-m^2\\ z&=4mnpq\\ r&=(p^2+m^2)(q^2+n^2). \end{aligned} \quad (3)$$

For convenience, we will call Eq. (2) Euler's identity.

Euler's identity is equivalent to taking the two rational sided right triangles, *abc* and *def*, where

$$a=p^2-m^2 \qquad d=q^2-n^2$$
$$b=2mp \qquad e=2nq$$

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[1] L. E. Dickson, History of the Theory of Numbers, Carnegie Institution of Washington, 1920

$$c=p^2+m^2 \qquad f=q^2+n^2$$

then multiplying the first triangle by e, the second by c, and substituting ea and eb for ec to form the three dimensional combination. But, there are four ways in which these two triangles can be combined to form rational solutions to the three-dimensional equation, as follows:

Combination	x	y	z	r
ce	cd	ea	eb	cf
bf	af	bd	eb	cf
cd	ce	bd	ad	cf
af	bf	ea	ad	cf

Combination bf is obtained merely by interchanging p and m with q and n in Euler's identity; combination cd leads to a new identity, given by Gill in 1826:

$$[2nq(p^2+m^2)]^2+[2mp(q^2-n^2)]^2+[(p^2-m^2)(q^2-n^2)]^2 = [(p^2+m^2)(q^2+n^2)]^2. \qquad (4)$$

Combination af is obtained by interchanging p and m with q and n in Gill's identity.

Thus, for each value of r in Eq. (3), there will usually be four solutions. However, sometimes, two or more of them will be alike, and sometimes, one or more will not be prime.

In the following example, abc is the 3-4-5 right triangle, and def is the 5-12-13 right triangle:

Combination	x	y	z	r
ce	25	36	48	65
bf	39	20	48	65
cd	60	20	15	65
af	52	36	15	65

But the combination cd is not prime: each term contains 5 as a common factor. This combination may therefore be reduced to 3-4-12-13. This is the smallest solution that can be formed by combining rational sided right triangles, but, contrary to the statement appearing in one place,[2] it is not the smallest solution possible. Table I, below, contains six solutions with r less than 13.

If x, y, and z be considered as Cartesian components of a

[2] W. C. Eells, *Amer. Math. Monthly*, *21*, 269 (1914).

vector, Euler's combination *ce* may be made to form a vector perpendicular to Gill's combination *cd* by interchanging y and z in one of them, and by changing the sign of x in either; a similar relation holds for combinations *bf* and *af*; thus:

$$\begin{aligned}(\pm cd\mathbf{i}+ea\mathbf{j}+eb\mathbf{k})\cdot(\mp ec\mathbf{i}+ad\mathbf{j}+bd\mathbf{k})&=ed(a^2+b^2-c^2)=0\\(\pm af\mathbf{i}+bd\mathbf{j}+eb\mathbf{k})\cdot(\mp bf\mathbf{i}+ad\mathbf{j}+ea\mathbf{k})&=ab(d^2+e^2-f^2)=0\end{aligned}\tag{5}$$

Lebesgue's Identity

The most general identity is believed to be that given by Lebesgue in 1868. To make the notation conform to that used above, the solutions obtained from Lebesgue's identity may be written as follows:

$$\begin{aligned}x&=(g^2+h^2)\left[q^2(p^2+m^2)-n^2(s^2+t^2)\right]\\y^2+z^2&=4n^2q^2(g^2+h^2)^2(p^2+m^2)(s^2+t^2)\\r&=(g^2+h^2)\left[q^2(p^2+m^2)+n^2(s^2+t^2)\right]\end{aligned}\tag{6}$$

where y^2+y^2 can be broken up into the sum of two squares in six different ways:

$$\begin{aligned}y_E&=2nq(g^2+h^2)(ps\pm mt)\\z_E&=2nq(g^2+h^2)(pt\mp ms)\end{aligned}\tag{6a}$$

(where the subscript is introduced merely to facilitate the writing of Eq. (9), below), and

$$\begin{aligned}y&=2nq\left[(pg\pm mh)(sg\pm th)\pm(ph\mp mg)(sh\mp tg)\right]\\z&=2nq\left[(pg\pm mh)(sh\mp tg)\mp(ph\mp mg)(sg\pm th)\right]\end{aligned}\tag{6b}$$

where the upper signs within the binomial factors go together, and the upper signs between them go together independently, so that Eq. (6b) represents four different combinations.

If we let $g=1$, $h=0$, $s=p$, and $t=m$, Eq. (6) reduces to Euler's identity.

Two Similar Identities

The relation between Lebesgue's and Euler's identities suggests that there may be other identities, similar to Lebesgue's from which Gill's identity may be derived as a special case. Two such identities, after removing the factor (g^2+h^2), which will be common to all the terms, yield the following solutions:

$$x_G=2nq(ps\pm mt)$$

$$\begin{aligned} y_G &= 2(mpq^2 \pm stn^2) \\ z_G &= q^2(p^2-m^2) - n^2(s^2-t^2) \\ r &= q^2(p^2+m^2) + n^2(s^2+t^2) \end{aligned} \tag{7}$$

and

$$\begin{aligned} x_F &= 2nq(pt \pm ms) \\ y_F &= 2(mpq^2 \mp stn^2) \\ z_F &= q^2(p^2-m^2) + n^2(s^2-t^2) \\ r &= q^2(p^2+m^2) + n^2(s^2+t^2) \end{aligned} \tag{8}$$

where, again, the subscripts are merely to facilitate the writing of Eq. (9), below.

Both Euler's and Gill's identities may be taken as special cases of either of these last two identities.

Thus, for each value of r given by Eq. (6), there will be ten solutions. From six of these, the factor (g^2+h^2) may be removed, as shown in Eq. (6a), (7), and (8); the other four solutions are shown in Eq. (6b). However, some of the solutions may not be prime, and, frequently, two or more will be alike. Thus, to prepare a lengthy table of prime solutions from these identities would be quite laborious.

The solutions given by Eq. (6a), (7), and (8) can be arranged to form perpendicular triplets of vectors; thus, using the upper signs in these three equations,

$$\left.\begin{aligned} &(x_E\mathbf{i} \pm y_E\mathbf{j} + z_E\mathbf{k}) \times (x_G\mathbf{i} \mp z_G\mathbf{j} + y_G\mathbf{k}) = r(-x_F\mathbf{i} \pm y_F\mathbf{j} + z_F\mathbf{k}) \\ &\text{and, using the lower signs:} \\ &(\pm x_E\mathbf{i} + y_E\mathbf{j} + z_E\mathbf{k}) \times (\mp x_G\mathbf{i} + z_G\mathbf{j} + y_G\mathbf{k}) = -r(x_F\mathbf{i} \pm y_F\mathbf{j} \mp z_F\mathbf{k}). \end{aligned}\right\} \tag{9}$$

The Identities of Cossali and of Catalan

Another old and well known identity is that proposed by Cossali in 1797:

$$[\alpha]^2 + [\alpha+1]^2 + [\alpha(\alpha+1]^2 = [\alpha^2+\alpha+1]^2. \tag{10}$$

This is but a special case of the more general identity,

$$[\alpha\beta]^2 + [\beta(\alpha+\beta)]^2 + [\alpha(\alpha+\beta)]^2 = [\alpha^2+\alpha\beta+\beta^2]^2. \tag{11}$$

Here, by permuting the components, and changing one sign, we can obtain perpendicular triplets; for example,

$$[\alpha\beta\mathbf{i}+\beta(\alpha+\beta)\mathbf{j}\pm\alpha(\alpha+\beta)\mathbf{k}]\times[\alpha(\alpha+\beta)\mathbf{i}+\alpha\beta\mathbf{j}\mp\beta(\alpha+\beta)\mathbf{k}$$
$$=r[\mp\beta(\alpha+\beta)\mathbf{i}\pm\alpha(\alpha+\beta)\mathbf{j}-\alpha\beta\mathbf{k}]. \quad (12)$$

Identity (11) is a particular case of

$$[\alpha\beta-\gamma(\alpha+\beta+\gamma)]^2+[(\beta+\gamma)(\alpha+\beta)]^2+[(\alpha+\gamma)(\alpha+\beta)]^2$$
$$=[\alpha^2+\beta^2+\gamma^2+\alpha\beta+\alpha\gamma+\beta\gamma]^2 \quad (13)$$

proposed by Catalan in 1865. No relation similar to Eq. (12) holds for Catalan's identity.

Eells' Table

In 1914, Eells[2] published a table of 125 solutions, using a method similar to Euler's or Gill's, giving all the relatively prime solutions obtainable from all values of his four parameters between 1 and 15. His work shows quite strikingly the limitations of any method based on combining rational sided right triangles. Only eight of his solutions have values of r less than 100, whereas there are 348 such solutions; only 24 have values of r less than 300, whereas, it seems to me, there must be approximately 3000 of them.

Table I. The Integral Solutions of $x^2+y^2+z^2=r^2$ for All the Odd Numbers between 1 and 100

x	y	z	r	x	y	z	r	x	y	z	r
1	2	2	3	4	5	20	21	5	6	30	31
				4	8	19	21	6	14	27	31
2	3	6	7	8	11	16	21	6	21	22	31
				4	13	16	21	14	18	21	31
1	4	8	9								
4	4	7	9	3	6	22	23	1	8	32	33
				3	14	18	23	4	7	32	33
2	6	9	11	6	13	18	23	8	8	31	33
6	6	7	11					7	16	28	33
				9	12	20	25	4	17	28	33
3	4	12	13	12	15	16	25	8	20	25	33
								17	20	20	33
2	5	14	15	2	7	26	27				
2	10	11	15	2	10	25	27	6	10	33	35
				2	14	23	27	1	18	30	35
1	12	12	17	10	10	23	27	6	17	30	35
8	9	12	17	7	14	22	27	15	18	26	35
6	6	17	19	3	16	24	29	3	8	36	37
1	6	18	19	11	12	24	29	3	24	28	37
6	10	15	19	12	16	21	29	12	21	28	37
								8	24	27	37

TABLE I. (*Continued*)

x	y	z	r	x	y	z	r	x	y	z	r
10	14	35	39	8	12	51	53	22	37	46	63
2	19	34	39	8	21	48	53	26	38	46	63
13	14	34	39	12	19	48	53	34	37	38	63
2	26	29	39	12	27	44	53				
14	22	29	39	12	36	37	53	7	24	60	65
19	22	26	39	27	28	36	53	20	24	57	65
								15	36	52	65
4	12	39	41	3	10	54	55	25	36	48	65
4	24	33	41	10	18	51	55	20	39	48	65
9	24	32	41	3	30	46	55				
12	24	31	41	18	26	45	55	6	22	63	67
23	24	24	41	6	35	42	55	14	18	63	67
				19	30	42	55	15	30	58	67
2	9	42	43					6	33	58	67
6	7	42	43	7	8	56	57	22	33	54	67
2	18	39	43	4	23	52	57	30	33	50	67
9	18	38	43	16	17	52	57	15	42	50	67
7	30	30	43	8	28	49	57	18	42	49	67
18	25	30	43	4	32	47	57	31	42	42	67
				16	28	47	57				
5	8	44	45	23	28	44	57	4	11	68	69
8	19	40	45	17	32	44	57	4	16	67	69
13	16	40	45	28	28	41	57	4	32	61	69
16	20	37	45	7	40	40	57	16	28	61	69
4	28	35	45	25	32	40	57	16	32	59	69
20	28	29	45					5	40	56	69
				6	9	58	59	28	29	56	69
6	18	43	47	6	14	57	59	16	37	56	69
11	18	42	47	9	22	54	59	20	35	56	69
2	21	42	47	6	23	54	59	4	44	53	69
6	27	38	47	9	30	50	59	11	44	52	69
18	21	38	47	6	41	42	59	35	40	44	69
18	27	34	47	14	39	42	59				
				30	30	41	59	3	26	66	71
4	9	48	49					18	19	66	71
12	24	41	49	12	21	56	61	3	46	54	71
15	24	40	49	3	24	56	61	10	45	54	71
23	24	36	49	21	24	52	61	19	42	54	71
4	33	36	49	24	28	48	61	30	35	54	71
9	32	36	49	11	36	48	61	18	46	51	71
12	31	36	49	20	36	45	61	26	42	51	71
				24	36	43	61	30	45	46	71
1	10	50	51								
2	14	49	51	5	10	62	63	1	12	72	73
14	14	47	51	2	11	62	63	8	9	72	73
1	22	46	51	2	22	59	63	12	12	71	73
10	10	49	51	11	22	58	63	12	33	64	73
14	17	46	51	2	34	53	63	8	36	63	73
1	34	38	51	22	26	53	63	24	28	63	73
14	31	38	51	5	38	50	63	12	44	57	73
22	31	34	51	10	37	50	63	28	36	57	73
				2	43	46	63	33	44	48	73

TABLE I. (*Continued*)

x	y	z	r	x	y	z	r	x	y	z	r
7	10	74	75	5	12	84	85	18	54	71	91
10	14	73	75	24	32	75	85	26	57	66	91
10	22	71	75	4	45	72	85	30	55	66	91
7	26	70	75	21	40	72	85	39	54	62	91
14	23	70	75	24	45	68	85	46	54	57	91
10	41	62	75	12	59	60	85	9	46	78	91
25	34	62	75								
22	46	55	75	2	18	81	83	4	13	92	93
34	38	55	75	18	18	79	83	8	11	92	93
38	41	50	75	18	33	74	83	8	29	88	93
				15	42	70	83	11	28	88	93
1	12	76	77	30	33	70	83	20	32	85	93
4	27	72	77	18	47	66	83	20	43	80	93
13	24	72	77	33	38	66	83	32	35	80	93
12	32	69	77	30	42	65	83	4	52	77	93
3	36	68	77	2	54	63	83	28	44	77	93
24	28	68	77	34	42	63	83	8	53	76	93
12	36	67	77	42	47	54	83	13	52	76	93
5	48	60	77					32	43	76	93
27	40	60	77	2	13	86	87	8	64	67	93
12	48	59	77	2	26	83	87	32	56	67	93
32	48	51	77	14	22	83	87	43	52	64	93
40	45	48	77	2	29	82	87	18	51	58	93
				13	26	82	87	52	53	56	93
6	11	78	79	19	22	82	87				
6	27	74	79	14	38	77	87	14	27	90	95
18	21	74	79	22	34	77	87	21	22	90	95
21	30	70	79	13	50	70	87	27	30	86	95
6	38	69	79	35	38	70	87	6	42	85	95
18	34	69	79	2	61	62	87	5	54	78	95
6	43	66	79	19	58	62	87	21	50	78	95
11	42	66	79	35	50	62	87	6	58	75	95
21	38	66	79	22	58	61	87	22	54	75	95
27	34	66	79					30	58	69	95
				9	28	84	89	42	50	69	95
8	16	79	81	17	24	84	89				
1	28	76	81	8	36	81	89	7	12	96	97
16	23	76	81	24	28	81	89	12	39	88	97
1	44	68	81	15	36	80	89	24	23	88	97
16	41	68	81	36	36	73	89	7	48	84	97
20	44	65	81	24	48	71	89	12	47	84	97
8	49	64	81	15	60	64	89	12	52	81	97
28	41	64	81	24	57	64	89	16	23	72	97
23	44	64	81	39	48	64	89	25	60	72	97
15	47	64	81	36	55	60	89	32	51	72	97
36	36	63	81					33	56	72	97
17	56	56	81	9	10	90	91	39	52	72	97
20	55	56	81	6	18	89	91	48	56	63	97
32	49	56	81	6	26	87	91	47	60	60	97
40	44	55	81	6	39	82	91				
32	51	52	81	6	4	73	91				

TABLE I. (*Concluded*)

x	y	z	r	x	y	z	r	x	y	z	r
1	14	98	99	14	47	86	99	10	65	74	99
14	14	97	99	31	38	86	99	46	47	74	99
10	26	95	99	26	49	82	99	31	58	74	99
2	31	94	99	31	46	82	99	1	70	70	99
17	26	94	99	14	58	79	99	26	65	70	99
2	49	86	99	38	46	79	99	49	50	70	99

For the preparation of this table, the writer used a method designed for rapidity and ease of computation, and to insure completeness in the interval covered.

Let x be the smallest component and z the largest. Then, let $r-z$ be a fixed number, k. Then

$$x^2+y^2=r^2-z^2=k(r+z)$$
$$=k(2z+k). \tag{14}$$

Then choose some value of x, and find the condition for which integral values of y and z satisfy Eq. (14). Then

$$z=(x^2+y^2-k^2)/2k. \tag{15}$$

For example, let $r-z=1$. Then $x^2+y^2=2z+1$. Then, if x be any even number, y may be any odd number (greater than x); if x be any odd number, y may be any even number (greater than x); in either case, $z=(x^2+y^2-1)/2$ and $r=z+1$.

If $r-z=2$, $x^2+y^2=4z+4$. Since all odd squares are of the form $4p+1$, no combination of odd squares can satisfy this condition. But, any pair of even squares will satisfy it, and, call-

TABLE II. VALUES OF z SATISFYING THE EQUATION $x^2+y^2+z^2=r^2$, FOR THE VALUE OF x AT THE HEAD OF EACH COLUMN AND FOR THE VALUE OF y AT THE LEFT OF EACH LINE, ARRANGED ACCORDING TO THE VALUE OF $r-z$

	$r-z=1$										
x	1	3	5	7	9		2	4	6	8	10
y						y					
2	2					1					
4	8	12				3	6				
6	18	22	30			5	14	20			
8	32	36	44	56		7	26	32	42		
10	50	54	62	74	90	9	42	48	58	72	
12	72	76	84	96	112	11	62	68	78	92	110
14	98	102	110	122	138	13	86	92	102	116	134
16	128	132	140	152	168	15	114	120	130	144	162

$r-z=2$

x	2	6	10	14	18		4	8	12	16	20
y						y					
6	9	17				4	7				
10	25	33	49			8	19	31			
14	49	57	73	97		12	39	51	71		
18	81	89	105	129	161	16	67	79	99	127	
22	121	129	145	169	201	20	103	115	135	163	189
26	169	177	193	217	249	24	147	159	179	207	243
30	225	233	249	273	305	28	199	211	231	259	295

$r-z=4$

x	2	6	10	14	18	22
y						
6		7				
10	11	15	23			
14	23	27	35	47		
18	39	43	51	63	79	
22	59	63	71	83	99	119
26	83	87	95	107	123	143
30	111	115	123	135	151	171

$r-z=5$

x	1	9	11	19	21		2	8	12	18	22
y						y					
12	12	20	24			9		12			
18	30	38	42			11		16			
22	46	54	58	82	90	19	34	40	48	66	
28	76	84	88	112	120	21	42	48	56	74	
32	100	108	112	136	144	29	82	88	96	114	130
38	142	150	154	178	186	31	94	100	108	126	142

x	3	7	13	17	23		4	6	14	16	24
y						y					
14	18	22	34			13	16	18			
16	24	28	40			17	28	30	46	52	
24	56	60	72	84	108	23	52	54	70	76	
26	66	70	82	94	118	27	72	74	90	96	128
34	114	118	130	142	166	33	108	110	126	132	164

In this table, x is the smallest number and z is the largest. In the blank spaces, there would appear values of z (including negative numbers) for which either one or the other or both of these conditions are not satisfied.

ing the smaller one x, we have $z=(x^2+y^2-4)/4$. However, in order to obtain relatively prime solutions, both x and y must be twice odd numbers, or, they must both be twice even numbers.

If $r-z=3$, no relatively prime solutions can be obtained.

The method is illustrated in Table II, above, for a few solutions for which k is 1, 2, 4, and 5.

This process was repeated for the values of k given below. The number of solutions for which r is less than 100 is also given.

$r-s$	Number of solutions	$r-s$	Number of solutions	$r-s$	Number of solutions
1	36	13	45	29	9
2	19	16	12	32	0
4	20	17	36	34	2
5	53	18	8	36	0
8	13	20	12	37	2
9	25	25	28	40	0
10	21	26	7	41	0
					Total 348

All odd values of r, except 1 and 5, have at least one solution. The distribution of the 348 solutions having values or r less than 100 is as follows:

Values of r							Number of solutions for each value of r	Total
1	5						0	0
3	7	13					1	3
9	11	15	17	25			2	10
19	23	29					3	9
21	31	35	37				4	16
27	41	65					5	15
39	43	45	47	53	55	85	6	42
33	49	61					7	21
59							8	8
51	67	71	73				9	36
75	79	95					10	30
57	83	89	91				11	44
63	69	77					12	36
97							13	13
87							14	14
81							16	16
93							17	17
99							18	18
								Total 348

THE PACIFIC CHEMICAL EXPOSITION

"The Pacific Chemical Exposition scheduled for the San Francisco Civic Auditorium for October 21–25, 1947, will be not only a western states, but an international event." says Paul H. Williams of the Shell Development Company and chairman of the exposition committee of the California Section of the American Chemical Society, as plans for the event progress. "San Francisco is centrally located for such a show and well supplied with transportation and hotel facilities and October is an ideal month for travel in this part of the world," says Mr. Williams.

THE EXHIBIT AS A SUPPLEMENTARY METHOD—VI: THE ATOMIC BOMB

HAROLD J. ABRAHAMS
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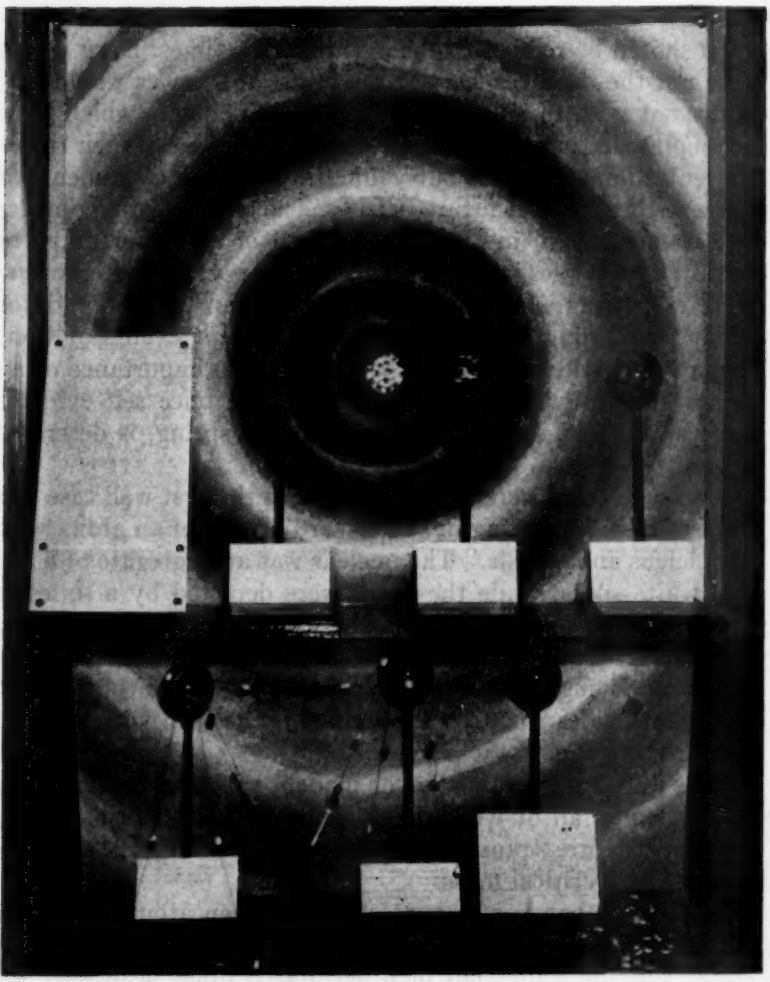
It is commonly accepted today that the work of the classroom should be related to the events of the times. Even if this were not the case, teachers of the physical sciences would certainly not wish to ignore the recent developments which have taken place in the realm of nuclear fission, because of their transcendental importance to our young people, both as students of those sciences, and as future citizens. Those not electing physics and chemistry are in still greater need of an opportunity to learn the principles involved in atomic energy, for, with no systematic instruction in this field, how else can they prepare for an understanding of the impact which recent events or their implications will have upon their lives? The importance of an exhibit which explains nuclear fission is at once self evident. Such an exhibit, set up at this school last spring, is described below.

Two wall cases were used. The back of the first wall case was covered with a painting in "show-card" color, of an atom, with its nucleus and "shells." The nucleus was an aggregate of black and white spots, while the shells were depicted by a series of blue, green, white, pink, red and violet concentric, blending bands. This painting served as a chart of atomic structure and as a beautifying background. It was edged across the top and down both sides with red satin ribbon, one inch wide, held in place by red thumb tacks.

This wall case contained seven models, with explanations, and main plaque, all of which explained the general principles of atomic structure, transmutation, isotopes, nuclear fission, chain reaction and critical mass.

Model number 1, representing a hydrogen atom, was made by bending the end of a piece of very stout steel wire into a circle, slipping a one-half inch perforated brass bead over the wire, then soldering the circle closed and bending the stem into an upright position, so as to conceal it behind the upright of the support of the model. This support was a wooden imitation of an iron ring stand and was painted with black enamel. The brass bead served as an electron. A glass sphere, made by blowing a bubble at the end of a piece of glass "connection-tubing," and

filled with a small piece of artist's wax, painted black, was fastened to the top of the upright of the ring stand and served as the proton. The steel wire orbit was centered around this proton



First Wall-Case. Models showing atomic structure and nuclear fission.

by bending it back to the center before making the final bend downward. Then it was fastened to the upright of the ring stand with black thread at several places.

Model number 2, representing the nucleus of an atom of U-235, was made by placing the appropriate number of black and white beans, representing neutrons and protons, into an amber-colored glass Christmas-tree ball, inverting and fastening it on to another wooden stand, by means of the blunt tube at its end.

Model number 3, representing the nucleus of an atom of U-238, was similarly set up, using a red-colored ball.

Model number 4, on the bottom shelf, was a repetition of model number 2, but it depicted radio activity. Black threads bearing protons and neutrons were fastened to the sphere at several places and a small paper arrow pointed *away* from the nucleus. These protons and electrons had to be made of artist's wax, painted black and white, as the beans used inside the glass sphere resisted having holes drilled into them without splitting.

Model number 5, was a repetition of number 3, again bearing threads with protons and neutrons, but this time the arrow pointed *toward* the nucleus, showing the nucleus under bombardment.

Model number 6 was a blue-colored glass ball set up on the usual wooden stand, and contained the appropriate number of black and white beans to make it represent the nucleus of an atom of U-239.

Model number 7 was a broken blue ball, resting on its side, the black and white beans scattered nearby, to represent fission.

The main plaque and the explanatory notes which accompanied the seven models in this wall case are given below:

Main Plaque—First Wall-Case

All matter is made up of molecules, which in turn consist of atoms. Atoms are composed of a center, (called a nucleus), and flying particles called planetary electrons, circling at tremendous speed around the center or nucleus. The nucleus consists of two kinds of particles, namely ***protons***, which are positively charged and ***neutrons***, which are electrically neutral. The flying particles (planetary electrons) circling the nucleus, are negatively charged and every atom has as many of them outside the nucleus as it has protons in the nucleus.

Planetary electrons travel along paths in which they stay constantly, except for some temporary condition, after which they return to those paths. Each chemical element has its own number of planetary electrons (so called because they travel like planets, around the sun). Only two electrons can travel in the first path or orbit. Thus if an element possesses 3 electrons, 2 will travel in the first orbit and 1 will travel in the second

orbit. The second orbit may contain a maximum of 8, the third 18, the fourth 32, the fifth 18, the sixth 12 and the seventh 2. To illustrate, suppose we select the metal aluminum. This element has 13 planetary electrons (and is therefore said to have an *atomic number of 13*). Two electrons will of course be in the first orbit, and since the second orbit can hold only 8 electrons, making a total of 10 thus far, there will have to be 3 electrons in the third orbit. The electrons will therefore be arranged 2—8—3.

The large painting which forms the background of this wall case is a diagram of the uranium atom. If numbers had been used in this painting, you should see 146 neutrons and 92 protons in the nucleus, and 92 electrons in the planetary system outside, arranged 2—8—18—32—18—12—2.

Since all elements consist of protons, electrons and neutrons, but in different quantities, the alchemist's dream of converting one metal into another—for example, lead into gold, is not as idle as it once appeared to be. The only knowledge needed is how to add or subtract these particles from an element to make it have the number present in the desired element. This practice, known to the alchemists of centuries ago as "*transmutation*" is now known to be possible. Mercury has 80 planetary electrons (and 80 protons in the nucleus) while gold has 79 of each. Scientists have succeeded in removing one electron and proton from mercury thus transmuting it into gold. We see then that elements differ from each other in chemical behavior because of the differing numbers of their planetary electrons (atomic numbers).

The same element can exist in several variations of the nucleus, however. These variations are called *isotopes*. Isotopes are varieties of the same element that differ only in the number of neutrons present in the nucleus. For example uranium, as stated before contains 146 neutrons, and 92 protons in the nucleus, and 92 electrons on the outside. It has therefore an atomic number of 92. But there is also a form of uranium which has 143 neutrons and 92 protons in the nucleus and 92 electrons on the outside—also therefore an atomic number of 92. Since the chemical behavior of an atom is due to its planetary electrons, both of these varieties or isotopes are uranium, because their atomic numbers are identical, i.e., 92. There is only one difference in physical properties—the isotope containing 146 neutrons and 92 protons has a weight of 238 and is therefore called U-238, while the isotope containing the 143 neutrons and 92 protons has a weight of 235 and is therefore called U-235. (Notice that 238 is the sum of 146+92 and that 235 is the sum of the 143+92. The electrons have so small a weight, that it may be neglected.)

Uranium 235 tends to give off neutrons. Uranium 238 can absorb these. When an atom of U-238 absorbs one neutron, it changes, by steps, into U-239, then plutonium. (Both uranium and plutonium are named after the planets Uranus and Pluto.) Plutonium is very explosive, when made into a piece of the correct size. This size is called "*critical mass.*" Smaller pieces are safe from explosion and for that reason the pieces of

plutonium used in the bomb are probably so arranged that they do not come together into a piece the size of the "critical mass," until after being dropped from the plane (see explanation in other wall case). The explosion of plutonium is explained below.

Accompanying Explanations

Model number 1. This is a model of the ordinary hydrogen atom. It shows one proton in the center and one electron on the outside. Hydrogen therefore has an atomic number of one. It is the only element which has no neutrons in its nucleus. (Another isotope of hydrogen is known. It has one neutron in its nucleus, and is called "heavy hydrogen," the extra neutron giving it additional weight. "Heavy water" contains this kind of hydrogen.)

Model number 2. The amber sphere represents the nucleus of an atom of U-235. The planetary electrons are missing from it and from all other uranium nuclei in this exhibit because of lack of space in the wall cases, but for a discussion of these electrons see the explanation which accompanies the exhibit.

Model number 3. The red sphere represents the nucleus of an atom of U-238.

Model number 4. This model represents the release of particles of matter from U-235, some of which are neutrons. Many of these go astray.

Model number 5. This model represents the bombardment of an atom of U-238 by particles released from an atom of U-235. If one neutron enters this nucleus, the isotope of uranium called U-239 will form.

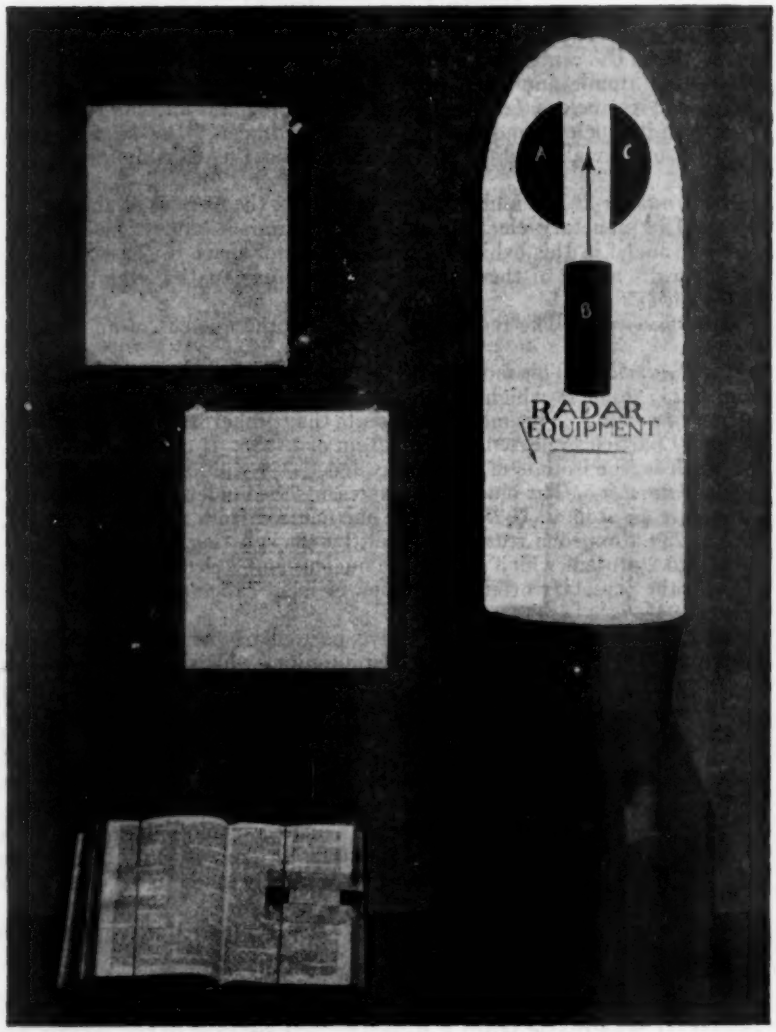
Model number 6. The blue sphere represents the nucleus of a U-239 atom, formed by an atom of U-238 gaining one neutron from an atom of U-235. This U-239 atom soon rearranges itself by the splitting of two of its neutrons into 2 protons which stay in the nucleus and 2 electrons which move out into the planetary orbits, into a new element called plutonium, atomic number 94.

Plutonium atoms are highly explosive, particularly when enough of them exist side by side. (The quantity of plutonium which is sufficient for a violent explosion is called "critical mass.") A plutonium atom gives off a neutron. If this strikes another atom of plutonium, the latter will split into two pieces. This splitting is called *atomic fission.* At the same time some of the atom is destroyed, releasing enormous quantities of energy, and more neutrons. These neutrons strike other plutonium atoms, making them also undergo *fission* with the release of energy and more neutrons. This constant release of, and bombardment by, neutrons of plutonium is called a *chain-reaction,* one atom causing other atoms to explode, until too few are left to do any damage. In this manner enormous amounts of energy are given off.

Model number 7. The broken blue sphere represents an atom of plutonium which has undergone atomic fission.

Wall-case number 2 contained a model of an imaginary atomic bomb. It was made from a longitudinal section of an Army Air Force concrete practice bomb, with the data shown in the illustration painted in black "show-card" on a white background of the same medium. The base and fins, as well as the rest of the outside of the bomb were painted blue-gray. A Bible, fastened open, by means of rubber bands, at the book of Micah, Chapter

4, rested next to the model of the bomb. A frame made of red satin ribbon was placed around the passage: "And they shall beat their swords into plough-shares, and their spears into



Second Wall-Case. Model showing probable details of the bomb.

pruning-knives: nation shall not lift up sword against nation, and they shall not learn any more war."

This wall-case also contained a plaque and an explanation of the bomb, as follows:

Explanation of Bomb

It is believed that when the bomb has descended to about 1500 feet, some secret mechanism forces the section of plutonium marked B on the bomb-model into its place between sections A and C. This produces a quantity of plutonium which exceeds the critical mass, and it therefore explodes, atomic fission setting in at a tremendous rate and continuing because of the fact that one exploding atom causes another to do likewise (chain-reaction).

In atomic fission, not only are two smaller atoms formed, but part of the atom is "destroyed," matter being converted into energy. Einstein's equation enables us to calculate how much energy can be released when a given weight of matter is thus converted.

$E = mc^2$—that is, the energy produced is equal to the weight of matter acted upon, times 90000000000000000000 (in the equation above, m stands for mass and c^2 for the velocity of light, squared).

We must agree that the ratio of weight to energy here shown staggers the imagination, and it is no wonder that a "small" piece of plutonium can do such untold damage.

Main Plaque—Second Wall-Case

At last man's capacity for evil has reached such heights of cunning that we are faced with the necessity of making either one irrevocable choice or another—no compromise is any longer possible. We must choose peace and walk the earth, like freemen, on our feet, or tolerate war and live slaves to fear, on our knees, in constant dread of being atomized by the most powerful, most ingenious, most impersonal weapon yet devised. Make no mistake—we *must* choose, we cannot wait until tomorrow, we dare not let others make the choice for us, lest it be the worst choice possible. At least in this sense, as well as in many others, the atomic bomb differs from all other engines of war. This weapon, unlike weapons of the past, compels us to make a choice—faces us with an "either-or."

The choice, among men of the twentieth century should not be hard to make. The alternative to universal peace fills the pages of history, and mankind needs no further experimentation to find out what results would follow. On the other hand there is every reason to hope that at last man has reached an era when everything conspires to make peace inevitable.

We have often heard it said that permanent peace is only a dream—that men will always fight—that fighting follows an instinct. The fascists have even said that war keeps a nation vigorous, young, strong, and have glorified death in battle as the sole duty of a soldier. Let us not forget that the same defeatism, the same pessimistic attitude retarded every advance in science—the eradication of children's diseases, the development of

swift methods of communication and transportation and so on. The best minds and hearts now believe that war and fighting are no more inevitable than are measles or the failure of a heavier-than-air machine to rise from the ground.

There is every reason to believe, that it would be possible to deliver the equivalent of 20,000 tons of T.N.T. (soon it will be a much greater amount) to your door step in peace-time either as a package through the mail, or as a rocket through the air from some far-off country with which we are formally at peace.

We are therefore at the cross-roads and must act immediately, to bring about a sensible and decent solution to the world-shaking problem posed by the invention of the atomic bomb.

The world must be organized for the use of atomic energy exclusively for peace. This organizing cannot take place by itself. You have a part to play, be it ever so small, in helping to bring about this much-desired result. Decide what that part is, and play it.

The exhibit seemed to justify itself, for no difficulty arose in connection with the class-room treatment of atomic structure and its newly-arisen application when that part of the term's work in chemistry was reached. The exhibit is both permanent and portable and will be useful for an indefinite period of time.

SIX YOUTHS WIN SCHOLARSHIPS FOR BETTER FARM METHODS

Six alert form youths, representing the states of Idaho, Indiana, Minnesota, Missouri, New York and Texas, were recently awarded $200 scholarships by the Westinghouse Educational Foundation as national champions in the 4-H Club Better Methods Electric Contest.

The four boys and two girls, judged as the best among 42 states winners in the nation-wide contest, were given the awards at a dinner in the Drake Hotel. They are: David E. McClun, 16, Preston, Ida.; Betty Lou Maymaker, 17, Indianapolis, Ind.; Raymond Reed, 20, Taylors Falls, Minn.; Shirley Peterman, 16, Miami, Mo.; Roger Gleason, 19, Groton, N. Y.; Harold Rampy, 17, Lakeview, Tex.

F. T. Whiting, Chicago, Vice President of the Westinghouse Electric Corporation, presided at the dinner which was part of the program of ths National 4-H Club Congress in session in Chicago December 1–5. Gueste included the 42 state winners, state 4-H leaders, and executives of power companies many of which have cooperated in the 4-H Better Methods project. This is the eleventh year that Westinghouse has been privileged to cooperate with the Extension Service and 4-H Club leaders in providing county awards, trips and scholarships.

W. G. Marshall, Pittsburgh, Vice President of Westinghouse, who announced the national winners and presented the scholarship certificates, sketched briefly some of the achievements of the six national winners.

MATCHING PEOPLE AND JOBS*

ARTHUR S. GREINER
Assistant Cashier, National Bank of Detroit, Detroit, Michigan

The theme of your meeting "new power, products, and personnel" gives me an opportunity to talk about a subject which should be of vital interest to both of us—the proper selection, training, and placement of our school graduates in jobs for which they are qualified. Perhaps I should change the phrase "of vital *interest* to both of us" to "a *responsibility* of both of us."

A study of the employment turnover figures of our recent high school graduates, in particular, shows too high a percentage for their own good or for ours. This I find is true in many other businesses and industries besides our own. It reflects, at first glance, the thought that these boys and girls are unable to adjust themselves to a working situation and perhaps there may be something in this inability to make the adjustment for us to talk about. We must be fair to the beginner, however, because in some cases working conditions and management policy are not always conducive to good adjustment. A beginner's job, no matter how pleasant the working conditions or how carefully the induction process is supervised, entails mostly routine repetitive work all day long. The recent student unconsciously compares this with the forty minute class periods which have aroused him periodically during his past four years. The more I look into this matter of adjustment the more I believe that this may be one of the factors that calls for "joint responsibility"—yours and mine. I have attended several meetings, recently sponsored by the Economic Club of Detroit, in which representatives of industry and education have attempted to "get together" to plan means by which they could, in some practical way, help solve each others' problems.

Most of you, I am sure, are familar with the work of the Economic Club's committee—and will agree that a sincere effort is being made by educators and business men to see the other fellow's problem—and propose a way of doing something about it. On this matter of occupational adjustment, one of the educators at a recent meeting made the following pleas:

1. That various businesses and industries furnish schools with job analy-

* Read before the Mathematics Section at the Annual Convention of the Central Association of Science and Mathematics Teachers, Detroit, November 29, 1946.

ses sufficiently detailed for intelligent classroom and counseling discussions.

2. That personnel managers make themselves available to help with student counseling.
3. That schools arrange student-teacher-personnel men conferences with small groups of students who through tests, counseling, and other means have indicated or shown preference for specific fields.
4. That business and industry make available to schools the opportunity for plant visitations—with best results to be expected where groups with specific interests visit industries paralleling these interests.
5. That business prepare printed vocational material for distribution to the schools.
6. That one of the principal complaints of business men was the poor work "attitude" of beginners—particularly their inability to get along with people and in this regard this educator suggested that schools spend a great deal more time on this phase of education.
7. That business must recognize this matter of adjustment and provide proper induction and training programs that will help these young men and women bridge the gap between school and work by establishing a warm and friendly feeling from the initial interview for a job right on down through the entire working situation.
8. That schools have an important job, too, in this regard, in teaching their young men and women how to apply for a job—discussing such matters as dress, general deportment, as well as helping the student to honestly evaluate his qualifications for the job he is seeking in his chosen field.
9. Summer work program for counselors.

The points are all well taken and deserve serious consideration and action.

We all like to think we are working under pressure these days, and perhaps we are, but we should never lose sight of the fact that those of us charged with the building and guidance of human beings should never let the excuse of "pressure" stand in the way of our prime duty.

This duty falls heavily on the shoulders of not only school counselors and teachers and personnel people but also very directly upon those charged with supervision on the job. The primary place, I think we'll all agree, for good training in morals and citizenship is, of course, the home. There has, however, been a sad drawing away from this basic teaching of love of God and country in the home and this has placed a heavier burden upon you and me in providing motivation towards an ideal.

Let's just briefly think about the problems and opportunities each of us in these groups—educators—personnel men and supervisors—have to face.

Educators—Teachers and counselors in most large schools have a real problem of working on a production line basis with overloaded classes every 40 minutes. I am always amazed that

any kind, even the most meagre, individual attention is possible. Some attempts are made to hold vocational study classes and in many of these instances business and professional people are invited in to visit with the classes. Often these visits, as far as the students are concerned, are just an opportunity to ease back for a period without doing any thinking. I have visited with groups of all sizes; from carefully selected small groups who have indicated through some preliminary screening process, a desire to hear about banking or clerical work as a career, to groups in lunch rooms or large study halls, jammed with students, 75% of whom don't have the slightest interest in the field of endeavor under discussion. At one large high school, I mentioned at the conclusion of an address to quite a large group that many psychological tests were available through their counselor to help them determine their aptitudes and interests—some enthusiasm seemed to be indicated by the group in this statement, but after the meeting the worried counselor explained to me that he had neither the time nor the facilities for this work. I am sure this is true in more than that particular school—where lack of funds or lack of planning does not permit time to be spent in testing and individual counseling with that great group of average boys and girls who are not going on to college and who have not formed any strong interests to direct them into a specific field, and they are just going to drift into the future—and into our industries.

Studies have shown that, on the average, fewer than 20% of people employed are in the right jobs—this is a real challenge to business and educators. The fact that around 80% of people employed are in jobs in which they are not interested or which they may even heartily dislike makes us stop a little to consider the matter of turnover and turnover costs—and remember that you and I, as consumers, are required to pay this cost and you and I as educators and personnel people can perhaps do something to help cut this cost.

As educators, more time spent in individual counseling, testing, and vocational guidance programs will pay real dividends in producing a greater share of contented workers.

As to *how* the time can be found for this, I'm sure I don't know. It's always so easy to suggest things for the other fellow to do and so seldom is our own house in order. However, from a rank layman's viewpoint, it does seem to me that more time must be found for guidance work even though it means curtail-

ing some of the refinements beyond the "three R's."

Since this is a meeting of mathematics and science teachers, perhaps I would not be out of order in making a plea for a review of some good sound basic arithmetic in the last year of high school—just some good old fashioned drills in some good old fashioned addition—subtraction—multiplication—and division. I understand one of our high schools here in Detroit has established a plan of running a series of basic arithmetic tests in the junior year and those not making satisfactory grades being obliged to take a refresher course in arithmetic during their senior year. I can assure you there is a real need for such tests and refresher courses. We have found it necessary in our training program to set up a schedule of arithmetic drills for our bookkeeper and teller classes.

Perhaps this is not the place to even mention the lack of proficiency in that grade school subject "spelling"—No! I guess I'd better not mention it. And as for penmanship—it has become a lost art!

Personnel Men

Now let's turn the spotlight on the second group who share this responsibility of matching people and jobs—the *personnel men*. Let's also consider just one general grouping of applicants —the largest group if you will—the high school graduates. Let's also narrow the field down to those applying for bank jobs—because these are the people with whom I am best acquainted.

Suppose we take a look at the group waiting in our reception room in response to an advertisement for high school graduates to be trained as commercial bookkeepers. There are from ten to fifteen young ladies waiting—dress and appearance ranging all the way from the girl with the stringy, unkempt hair, dirty finger nails, plaid flannel boy's shirt, and moccasins to the one or two at the other end of the range who have given some thought to presenting a neat, business-like appearance. After any such advertisement has run its course, our walls, particularly the entrance corridor, bear the current announcement "Kilroy was here."

The receptionist directs each of the applicants individually to the initial interviewer who screens out many, mostly because of poor attitude and appearance. Those who pass muster on this short first interview are referred back to the receptionist who assists them in the preparation of the application blank and

administers a short form intelligence test. If this test grades above our minimum standard, a further test battery is given which includes a standard test of clerical aptitudes and some practical arithmetic problems. These tests are graded at once and returned to the interviewer together with the application and after he has quickly scanned the test results the applicant is recalled and the interviewer spends the needed time discussing the information on the application and the applicant's qualifications for this job as measured against the job specifications. Most interviewers are careful to check into the following points:

1. *The work history*
   With high school applicants this is, of course, limited to part time jobs she has held. However, many times even with these limited job experiences, undesirable personality traits are uncovered. References are always obtained from previous employers, directly by telephone wherever possible.
2. *Educational background*
   School grades—best and poorest subjects—school activities and interests.
3. *Social background*
   Home atmosphere—clubs and social activities.
4. *Health*
   General health—recent illnesses—any serious illness or handicap—methods used to maintain health.
5. *Personality*
   Not only poise and appearance—but ability to meet and talk with people—ability to "get along" as brought out in discussions of previous jobs or school situations.

At this stage we might stop for just a moment to consider the time and research that a bank or any other business spends in selecting a new installation of machinery or the study that goes into the selection of an investment for surplus funds. Let's be honest with ourselves (we in business) and determine whether we spend enough time in the selection of our human investments—men and women who, we hope, will be with us longer than any of the machines—and far more important, too. I think it is far less cruel to reject someone not fitted for a job at the outset rather than permit him to struggle on through the years doing a half-hearted job that usually ends in failure and frustration. I do honestly think that we and most other progressive businesses are giving more thought and consideration to this problem of selection and placement—just as I know that you in the schools are using and developing new techniques in this most important field. The industrial relations sections of our great universities have been the laboratories for the greatest share of

advances in this science. My point, however, is that advances in this field of human relations have not kept pace with advances in other sciences.

To illustrate procedure at our organization, let's follow an applicant who has been selected through to actual placement on the job—in the example we are using, remember the job is commercial bookkeeping. The applicant is introduced to the instructor of the bookkeeping training section who attempts to make the newcomer feel at home and assigns work that she can perform until the complete class is organized—usually within the next day or two.

Our initial bookkeeping training program covers a period of four weeks of segregated classroom training followed by a closely supervised on-the-job training with each trainee under the individual guidance of a specially selected and trained sponsor.

The initial four weeks are broken up into three general phases:

1. *Orientation*
   Getting acquainted with the bank—its history—its management —and services. This includes a conducted trip to all departments where each department manager is alerted to present the functions of his department to the class. Orientation also includes making the group acquainted with our rules of conduct and the various employees' services and benefits. This get-acquainted material is presented over the entire four weeks of vestibule training.
2. *Machine Training*
   Here, step by step, the girls learn to operate the bookkeeping machines. Practice sets have been developed in which every type of bookkeeping situation will be met.
3. *Lectures and Discussions*
   Wherever possible all lectures are illustrated with slides, slidefilms, charts, and blackboard. We call upon various department heads to lead these discussions wherever the topics dip into their special fields. For example—ability to recognize and identify signatures is a very important part of a bank bookkeeper's duties. To supplement the lecture of our expert in this field, we prepare slides from copies of checks placed side by side with specimen signature cards—in many cases ten to fifteen years had elapsed between the signing of the two and through this means we are able to point out that "characteristics" seldom vary. A sprinkling of actual forgeries are also prepared in the same manner and inserted with the other slides.

Careful progress records are maintained of both mechanical proficiency on the bookkeeping machine and of the group's assimilation of related banking knowledge. Much individual counseling is done by our instructor in matters of dress and office deportment. When the girls have completed their segregated classroom training they are, as I mentioned earlier, placed for their first on-the-job experience with a trained and sympathetic sponsor.

A follow-up for a period of six months is maintained by our Training Division to not only check progress but also to evaluate our testing and selection program as well as instruction methods. We hold occasional meetings of our sponsors and have through this means gained many valuable training suggestions. It is worth noting that those who have served as sponsors have invaribly grown into better workers and frequently into better jobs.

Supervisors

Now let's turn to the third group that I earlier mentioned should share some of the responsibility with the educator and the personnel man in developing successful and contented employees—I refer to the *supervisor*. He's the man who can either continue to help the worker build and grow or tear down all that top management has tried to instill in the beginner through an expensive training program.

Many supervisors, in the past, have been selected because "they knew the job." This is, however, just *one* of the qualities of a supervisor. He must be a *leader*—not a boss, which means he must be well grounded in a basic knowldege of human relations—this is a skill which requires training. He must be an *instructor*—the best part of his time is spent in "telling and showing" others—this, too, is a skill and requires training. Management and men both expect him to be constantly developing *methods improvement*—again this is a skill that requires study and training. To many employees the supervisor's job seems soft—but believe me he's the key man—often in the past, a forgotten man.

Most industries, including ours, are spending more and more time in developing and building the men and women who carry out the job of management through the medium of a group of people working together as a team.

The expansion of industry during the war drove home the need for supervisory training. The Training within Industry (Division of War Manpower Commission) developed some "quickie" courses to help new supervisors acquire some of the basic skills which I just enumerated. These short courses accomplished a great deal in a time when speed in everything was essential. We are still using these quickie programs with our new supervisors—they're good—and since they absolutely require

group participation they serve as a springboard to further supervisory meetings.

At our office, our supervisory meetings cover discussions of policy matters, operational problems, personnel questions, service functions of other departments, human relations problems, basic economics, and discussion of the general business structure, etc.

In addition to helping develop a more balanced thinking, these meetings give management an opportunity to observe these men and women at close range and away from their departments. A by-product of these meetings—and a mighty important by-product—is the reflection of worker attitudes back to management.

These meetings of supervisory people cannot help but develop a greater feeling of responsibility on the part of the supervisor which in turn should reflect itself in decreased turnover and increased efficiency—and because these leaders will realize the part the schools and personnel people are doing in training and placement—and instead of being the weak link in this important chain, will more and more become conscious of the human factor and the need for continuing the training and guidance program —right to the point where the trainee eventually backs his supervisor out of his job—and right here, let me stress that from observation and study I have noted that such supervisors when pushed out of jobs by well trained understudies are always pushed up and not out.

If all three of the groups, teachers—personnel people—supervisors, understand their responsibilities to these young people and make a sincere effort at intelligent guidance, I am certain that much costly turnover will be eliminated and, more important, workers placed on jobs they like and are qualified to do.

I am sure that we here in this room can help do our share for this world of new power and new products by concentrating on the most important factor—the human factor.

A NEW HEAT LAMP

Infra-red heat lamp, now improved with a bulb of hard glass to insure safety and with a ruby-hued filter to reduce glare, fits into any ordinary household socket. While designed for home heat-treatment of aching muscles, it has many other heat applications, such as drying hair.

STATE PUBLICATIONS FOR TEACHERS OF SCIENCE

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The writer had a particular interest in ascertaining the efforts being made by the departments of education of the several states to assist classroom teachers, supervisors and administrators engaged in science education.

The particular phase of interest of this investigation was to make a brief survey of various syllabi and other publications prepared for the use of personnel concerned with the teaching of science to determine the extent to which these publications attempted to suggest courses of study, list aims, objectives, etc. for the public schools.

Letters were sent to the "Directors of Instructional Supervision" of each of the 48 states requesting syllabi, courses of instruction, and any other publications prepared by the state departments of education in the field of science. One month later the writer tabulated the replies received and dispatched a second letter to those states from which no reply had been received. A month following the sending of the second letter the replies and material received were analyzed and a final tabulation was made.

In no case was it found that a state imposed a specific course of study in science. In the majority of cases, it was found that state departments of education did not have publications available specifically for science. Many reasons were given. The reason appearing most frequently is best illustrated by an extract from the communication from the Department of Education of Rhode Island:

> "In reply to your recent communication may I state that there are no statewide courses of study, textbook adoptions, etc. in Rhode Island. All such matters are left by law in the hands of the local school authorities."

Nine states failed to make any reply whatsoever. Eight states reported syllabi out-of-print or obsolete while seven reported syllabi in revision or development.

Many types of publications were received and analyzed. Some of these were quite in detail making many specific suggestions and presenting definite course outlines. Others presented only generalized objectives for the public school science program.

From the publications received from the various states a chart was made up covering the following items: State and Course, Date, Aims and Objectives, Suggested Units of Study, Relatively Detailed Course Outlines, Bibliography for Students, Bibliography for Teachers, Suggested List of Equipment and Supplies, Suggested Experiments, Suggested Activities, Suggested Visual Aids, Science Vocabulary, Proposed Laboratory Lay-Out or Floor Plan, Suggested Evaluative Techniques. It must be emphasized that the appearance of certain items in different syllabi does not assume equivalence. In certain publications aims were definitely stated, in others they were implied.

While no effort was made to rate the various state publications, the writer suggests that the syllabi prepared by the Departments of Education of New York, Tennessee, and Vermont may well be examined by all educators interested in science teaching. These syllabi seem to be the most complete and the most definite of all the publications received and seem to present much of value for the classroom teacher. New York lists not only a syllabus for biology, chemistry, physics, and radio but gives a detailed outline for the work in Grades 1 to 6 as well. A new syllabus for 7th, 8th and 9th year general science is in preparation for 1947.

A NEW SOUND FILM

A new educational sound film, "Clear Track Ahead!", telling the story of railroad transportation from the days of the picturesque "John Bull" locomotive of a century ago to the gigantic streamlined steam, electric and diesel engines of the present time, has been completed and is now available without charge for showing to school assemblies, social studies classes, Parent-Teacher Association meetings, and other gatherings, the Pennsylvania Railroad announced today.

Photographed during the past Summer, this documentary motion picture describes the men who run the trains and includes many interesting and informative action scenes taken in the railroad's yards, terminals, shops and laboratories, and along the right-of-way.

Such new improvements in services and equipment as the coast-to-coast sleeping cars, cab signal indicators, train telephones, and the automatic devices used in the classification yards are shown and explained, as are many other facilities developed for the comfort and safety of the railroad's passengers and the speedy delivery of its freight.

"Clear Track Ahead!" runs approximately 25 minutes in its 16 millimeter form for non-theoretical use. It may be booked for showings anywhere in the United States through G. E. Payne, System Publicity Representative, Pennsylvania Railroad, Room 1587, Broad Steet Station Building, Philadelphia 4, Pa.

PUTTING THE "SIMPLE" IN SIMPLE HARMONIC MOTION

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Students and teachers are agreed that one of the most difficult topics to explain satisfactorily in an elementary course is simple harmonic motion. A brief survey of texts shows that they share the common fault of getting too involved in the "circle of reference"; and then forgetting to point out clearly why we may apply the results of the "circle of reference" analysis to particular problems, such as the simple pendulum. Then the helical spring or other examples may be discussed in disconnected fashion. The result for the student is a loosely connected conglomeration of *somehow* related hypothetical geometrical construction and application of the laws of motion to several examples, culminating in "formulas."

Let us begin with a clear-cut definition of simple harmonic motion as the periodic (or repeating) motion in a straight line of a particle (or rigid mass) whose acceleration is always proportional (and oppositely directed) to its displacement from an equilibrium position. Symbolically:

$$a \propto -x. \tag{1}$$

The student will recognize this as embracing Hooke's law for elastic bodies ($F = kx$).

What about the "circle of reference?" Let us construct such a circle with a reference particle moving about its circumference at a constant speed. The projection of this reference particle on any diameter obviously moves with an acceleration which is the projection on that diameter of the acceleration of the reference particle. Next may be recalled, by repetition of the proof, if necessary, that the acceleration of the reference particle is equal to $\omega^2 r$, and directed radially inward. ω is the "periodic velocity" (2π times the frequency) of either body; and r is the radius of the circle of reference or the amplitude of the S.H.M. The acceleration of the projection is:

$$a = -\omega^2 r \cos\theta = -\omega^2 r x/r = -\omega^2 x \tag{2}$$

x is the displacement of the projection from the center of the circle; θ is the angle between the radius drawn to the reference particle and the diameter projected upon.

Here the point that is often overlooked or taken for granted may be emphasized: The acceleration of this projection is proportional and oppositely directed to the displacement! This is just the condition (1) by which we have defined S.H.M. Thus, if we identify the center of the circle of reference with the position of equilibrium, our projection performs S.H.M. along the diameter. Conversely then, we are justified in using the circle of reference to analyze any S.H.M.

It is generally considered desirable to derive expressions for the period for several cases of S.H.M. The expression for the period:

$$T=2\pi/\omega \tag{3}$$

may be clarified by recalling that (constant) speed is distance/time. Then $v=\omega r=2\pi r/T$; where $2\pi r$ is the distance traveled in time T. $v=\omega r$ may be shown to spring directly from the definition of radian measure. Eliminating ω between (2) and (3), we have:

$$T=2\pi\sqrt{x/-a}. \tag{4}$$

For the specific cases, we need only evaluate a. For an elastic body obeying Hooke's law:

$$F=ma=-kx \tag{5}$$

$$a=-kx/m$$

$$T=2\pi\sqrt{m/k}. \tag{6}$$

For the simple pendulum, it must first be shown that we have S.H.M. From the laws of motion: $F=ma=-mg\ sin\ \theta=-mgx/l$ (very nearly for small θ). Thus, $a=-(g/l)x$; where x is the displacement along the arc, and l is the pendulum length. As (g/l) is constant, we have condition (1), the stated condition for *S.H.M.* Substituting for a in (4):

$$T=2\pi\sqrt{l/g}. \tag{6'}$$

We might have used mg/l for k in (5) to arrive at the same result.

If the period of a compound pendulum is desired, it is necessary to introduce rotational quantities. For (1):

$$\alpha\propto-\theta. \tag{1'}$$

For (4):

(4′) $$T = 2\pi\sqrt{\theta/-\alpha}.$$

From the laws of motion:

(5′) $L = I\alpha = -mgl\theta$ (very nearly for small θ)

L is the torque; mg is the force; $l\theta$ is the lever-arm, very nearly; $I\alpha$ is the kinetic reaction. Eliminating α and θ between (4′) and (5′):

(6″) $$T = 2\pi\sqrt{I/mgl}.$$

The simple pendulum may also be considered as a special case of the compound pendulum where $I = ml^2$.

THE FUNCTION OF A RADIO CLUB IN THE JUNIOR HIGH SCHOOL

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My original feeling in sponsoring a club of this type at the junior high school level was one of misgiving and uncertainty. The misgiving emanated from the thought that it might be too technical for all but a very few of our members. And the uncertainty stemmed from the consideration that it might not have a rightful place at our educational level.

After two years of working with this group, I find that my fears have been completely dispelled. Now I am a firm proponent of the idea that our kind of radio club fits in as a legitimate junior high school extracurricular activity. A glance at the varied programs of the past year will disclose the reason for this contention.

Our meetings devoted themselves to the following agenda:

1. *A simple communications demonstration.* Two telegraph keys and a sounder were hooked up in series with several dry cells. A few members familiar with Morse code demonstrated sending and receiving.

2. *A spark coil demonstration.* One club member showed that radio-frequency waves were emitted when electricity sparked across the two terminals of the induction coil. The emission was vividly shown when he brought a neon bulb near the spark gap and it glowed.

3. *Technique of soldering radio leads and parts.* A student ac-

tually employed on a part-time basis in a local radio store showed how an electric soldering iron was prepared for use, how the flux functioned, and how the solder was applied to make good joints.

4. *Showing of a sound film entitled "Electrons on Parade."* A portrayal of electronics and its multifarious uses.

5. *An exhibit of the different parts that go into a radio.* Condensers of different types, coils, resistors, tubes, knobs, dials, shielding, etc. An explanation was given of the role each part assumed in the operation of a set.

6. *A series of talks on sources of technical information.* Copies of publications dealing with radio were displayed, and various members spoke about the content and range of subject matter in specific periodicals. Included were such magazines as *QST*, *Radio News*, *Popular Mechanics*, *The Radio Amateurs' Handbook*, *The Popular Science Radio Annual*, and *The Radio Amateurs' License Manual.* Also mentioned were various elementary books on radio that could be obtained from the library.

7. *A demonstrated talk on the vacuum tube.* By reference to a handbook on tubes, a student showed how one could find the function and purpose of any tube. He selected at random several tubes from an accumulated collection of old ones, pointed out the number of each, and then looked up its characteristics. In addition, he showed how the various prongs could be identified on the standard octal base.

8. A *sound film entitled "Frequency Modulation."* Excellent animation of amplitude-modulated and frequency-modulated waves was illustrated. Also graphically depicted were the advantages of FM over AM.

9. *Demonstration and manipulation of a crystal receiver built by one of our members.* The student showed that there was a sensitive spot on the galena crystal which had to be located with the cat's whisker. Different students had an opportunity to put on the headset and tried their luck at finding the "live" spot.

10. *Demonstration of visual communication.* Using a Boy Scout flashlight, a member indicated how the Morse Code signals could be flashed from one point to another. He was careful to point out both the advantages and disadvantages of this type of signalling both in war and in peace.

11. *A survey of the sound amplification system used in the school auditorium.* The entire club was involved in this project. It consisted in analyzing the operation of the following parts: a crystal

microphone, a 17 watt amplifier, four permanent magnet speakers, and the wiring problem. Also taken into consideration were the acoustical properties of our assembly hall.

12. *The sending and receiving of the International Morse Code.* A half dozen meetings were conveniently interspersed between the above-mentioned gatherings, and were solely devoted to this aspect of communications.

For the coming year with the greater availability of hard-to-get parts, we are embarking on a slightly more ambitious program. We expect to build one-tube radio receivers and our more able members will more than likely become involved in a joint project of completing a set composed of several tubes.

To say that our organization is now a going concern is to put it mildly. One of our recent members, and now a graduate, visited us recently. He pulled from his pocket the circuit diagrams for a transmitter which he maintains will enable a broadcasting station to transmit an unlimited number of programs simultaneously. Although he had not built a model of his device and therefore could not prove the workability of it, he oozed so much confidence and enthusiasm that it literally infected me. We went into the school office together and showed his plans to the principal. The latter directed the boy to the laboratory of a well-known college of engineering in our community in order to have his work inspected. Before the lad left I pointed out that a recent article appeared in which a prominent laboratory revealed the development of a system called pulse-time modulation. According to this system it would be possible to transmit sixteen broadcasts at one time. The boy was quick to point out that his method would result in the simultaneous transmittal of an infinite number of programs!

Whether this student does or does not have something on the ball in this instance, we could not help but feel justly proud that we had helped to direct his interests through membership in a school club.

Another of our former members who had moved to another city recently dropped in and informed us that he was studying to be a radio technician at the technical high school in his newly-adopted city.

All of the aforementioned leads us to believe that a technical club at the junior high level can survive if it doesn't become too technical. It can challenge the interests of its members by affording them the opportunity of developing a variety of radio

skills and knowledge at a level where it will have meaning for them. And too, it can be broad enough in its scope to appeal to a wide cross-section of students with differing abilities.

A METHOD FOR TEACHING FORMULA WRITING AND STRUCTURAL DIAGRAMING IN HIGH SCHOOL CHEMISTRY*

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The first article outlined a method that might be used with binary acids. This article outlines a similar method that may be used in writing formulae and structural diagraming for trinary acids. Trinary acids contain three and only three elements. Most of the acids of the trinary type encountered in high school chemistry are meta or ortho acids. Acids containing oxygen are known as oxy-acids and may be either meta acids or ortho acids. For purposes of classification let us consider the following three categories:

1. Oxy-acids (contain oxygen) (These are usually meta acids.)
   a. lowest of four valences (oxidation states of the central or acidic element)—Hypo (central element) ous acids, e.g., Hypo *chlorous* acid, $HClO$.
   b. lowest of two valences (oxidation states of the central or acidic element)—(central element) ous acids, e.g., *Chlorous* acid, $HClO_2$.
   c. highest of 2 or 3 valences (oxidation states of the central or acidic element)—(central element) ic acids, e.g., *Chloric* acid, $HClO_3$.
   d. highest of four valences (oxidation states of the central or acidic element)—per (central element) ic acids, e.g., per *chloric* acid, $HClO_4$.
2. Meta acids—contain one molecule of the oxide and one molecule of water, e.g., $SO_3+H_2O=H_2SO_4$ (sulfuric acid).
3. Ortho acids—contain one molecule of the oxide and three molecules of water, e.g., $P_2O_5+H_2O+H_2O+H_2O=H_3PO_4$ (ortho phosphoric acid after simplification).

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* This is the second in a series of three articles.

The following are the steps to be taken in writing formulas for trinary acids:

1. Write the formula of the oxide as indicated by the ending of the name.
2. Simplify the oxide.
3. Add, algebraically, the proper amount of water.
4. Simplify the resulting formula.

The following cases illustrate the steps to be taken:

Case I. Perchloric acid (the valences or oxidation states of chlorine with oxygen are 1, 3, 5, and 7)

1. $Cl^{7}O^{2}$ (valences written as exponents)
   Cl_2O_7 (valences crisscrossed)
2. Cl_2O_7 (cannot be simplified)
3. $Cl_2O_7+H_2O=H_2Cl_2O_8$ (a meta acid)
4. $HClO_4$ (simplified)

Case II. Sulfuric acid (the valences or oxidation states of sulfur with oxygen are 2, 4, and 6)

1. $S^{6}O^{2}$ (valences written as exponents)
   S_2O_6 (valences crisscrossed)
2. SO_3 (simplified)
3. $SO_3+H_2O=H_2SO_4$ (a meta acid)
4. H_2SO_4 (cannot be simplified)

Case III. Phosphoric acid or ortho phosphoric acid (calls for a valence of 5 for phosphorus)

1. $P^{5}O^{2}$ (valences written as exponents)
   P_2O_5 (valences crisscrossed)
2. P_2O_5 (cannot be simplified)
3. $P_2O_5+H_2O+H_2O+H_2O=H_6P_2O_8$ (an ortho acid)
4. H_3PO_4 (simplified)

In drawing the structural diagram for a trinary acid proceed as follows:

1. Determine the correct empirical formula by the above method.
2. Set down as many atoms of the central or acidic as are indicated by the formula.
3. Using short straight lines, indicate the valence of the central or acidic element, one line for each valence. (This is always the valence of the central or acidic element used in determining the formula for the oxide.)

4. In the case of two or more atoms of the acidic element, join these atoms with atoms of oxygen.
5. By means of oxygen attach hydrogen to the central or acidic element.
6. Check by counting the number of individual atoms. If this is not the same as in the empirical formula, either that formula is wrong, or you have made a mistake in drawing the structural diagram.

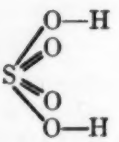
Case II. Sulfuric acid:

1. H_2SO_4

2. S

3. S

4. S



Sample Case with two central atoms:

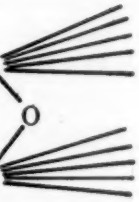
1. $H_2Cr_2O_7$ (dichromic acid)

2. Cr
   Cr

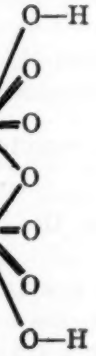
3. Cr

   Cr

4. Cr



5. Cr



The foundation of every state is the education of Youth.

NOTES FROM A MATHEMATICS CLASSROOM

JOSEPH A. NYBERG
Hyde Park High School, Chicago

126. A Problem Involving Several Fields. One of the complaints about high school mathematics is that it has been divided into compartments which seem to have few connections. Unified or correlated mathematics assumes that various units like factoring, congruent triangles, graphs, sets of equations, as well as trigonometry can be taught as different aspects of one great idea—functions, for example. These attempts at unification have never been successful because there are few problems in the elementary field that use ideas from several compartments. The problem suggested below involves a few compartments and is suitable for the third semester of algebra.

Find the equation of the parabola $y=ax^2+bx+c$ that passes through the points $(-3, 28)$, $(2.5, -20)$, $(4, 24)$. Draw the graph. For what values of x will $y=0$? What is the smallest value of y?

The pupil must (a) solve a set of three equations; (b) draw a graph; (c) solve a quadratic equation by the formula; (d) know that the minimum value of y corresponds to $x=-\frac{1}{2}b/a$. In order that logarithms will also be used, the coordinates of the given points are so chosen that a, b, and c will not be integral. For the above example

$$y=5.44x^2-6.01x-39.0.$$

To make sure that the pupils will not subdivide and share the work, each pupil is given different data. This is done by having the data written on a 3×5 card, one given to each pupil. The cards are then collected and used next semester. Since four or five hours of work are needed to complete the task this is not an over-night assignment. During a period of years I have collected from various pupils a set of correct solutions enabling me to check easily the work hereafter.

127. The Three Cases of Percentage. In the *Journal of Educational Research*, Oct., 1946, is a report of a test on percentage problems given to some college freshmen. The wrong answers are classified and analyzed. For the problem "88% of 1.75 is . . . " 13 % were wrong because of lack of understanding of the procedure involved. For the problem "20 games is what per cent of 25 games?" 17% were wrong because of lack of understanding

of the procedure involved. For the problem "3.4% of . . . equals 68" 34% were wrong for that same reason.

The three cases of percentage are taught in the eighth grade and a different rule of procedure is taught for each case. Textbooks are not backward about putting plenty of meaning into the concepts. The pages are full of squares divided into hundredths and of lines marked "whole" and "part," and so forth and so forth, to make sure that the pupil will understand the relations among the three numbers. There are of course the three distinct rules. In one case, you multiply; in another case, you divide; and in division the result depends on selecting the dividend correctly. It is not surprising that the pupil confuses three rules when trying to recall them.

In the ninth grade most textbooks base the work on the formula $p = br$. Books on pedagogy emphasize that " . . . pupils should be brought to realize that the one fundamental principle that underlies all percentage problems is: base times rate equals percentage, or $br = p$." And there, I think, is where the trouble begins. The rule is useless and the formula is useless unless the pupil can decide which number in the problem is p and which number is b. This difficulty does not arise with a formula like $A = lw$ since a pupil is unlikely to confuse a length with an area. Likewise, a pupil does not confuse a radius of a circle with its area. With $i = prt$ he does not confuse p, which is stated in dollars, with t, which is stated in years. Note that the word *percentage* is itself misleading since it suggests *per cent*. Teachers who use $p = br$ should make sure that the pupils can select p and b in a problem. (Write ten problems on the board and tell the pupils not to solve them but merely to state which is p and which is b.) It would help the pupil to be told that in a practical problem the percentage and the base are *like* quantities. If b represents oranges then p is also oranges; if p is gallons then b is also gallons. This idea does not isolate the number p but at least it isolates the number r. Neither does this idea help when p and b are not concrete numbers.

In the ninth grade these percentage problems need not be based on the formula $p = br$. I would discard it entirely; I would also discard the terminology about *percentage*, *base*, and *rate*. I would say to the class something like this: "Once you studied three kinds of problems using per cents, and you doubtless had much grief learning three rules—a separate one for each kind of problem. Because you have now learned something about

algebra you need no longer worry about the three rules. You can solve all the problems in one simple way, namely, write the problem as an equation and solve the equation."

Note here the strong motivation for learning algebra—a much better motivation than pictures of architects and chemists and physicists and engineers, a much better motivation than a sermon about the importance of mathematics in modern life. Further, instead of making algebra appear like arithmetic done in a hard way as often happens (why should a pupil use an equation to find a number which is 6 less than 37?), this application shows that algebra makes the problems of arithmetic easier.

I would discuss with the class the three types:

What number is 8% of 75?	$x = .08(75)$
12 is what per cent of 85?	$12 = x(85)$
20 is 3% of what number?	$20 = .03(x)$

Nothing is said about p, b, and r. Nothing is said about any formula. Nothing is said about base, or rate, or percentage. The only rule is: Write the equation and solve it. Although I am an ardent advocate of generalizing, in this case I prefer not to derive a rule for each type of problem. A pupil cannot confuse rules that he has never heard.

128. Which Verbal Problems? There has always been much agitation against the "answer known" type of verbal problems, that is, problems in which the given information would in real life be obtained from the answer rather than the answer obtained from the data. Age problems are typical of this kind. Other kinds, such as coin and clock problems, are in disrepute because they lack reality.

But the *real* problems are too few or too difficult or are pedagogically unfit for a variety of reasons. Some writers suggest that the answer known variety be treated frankly as puzzles since children like puzzles. Or the wording of these problems could be varied to make them appear real, such as asking: Could some nickels and dimes be worth \$2.80 if there were 40 coins in all? Or, if a father is 40 years old and his son 10 years, in how many years will the father be twice as old as his son?

Instead of using reality as a criterion for selecting problems I suggest: Are the equations to which the problems lead based on some universal truth or on some fact which is true only for the particular problem. To illustrate:

The sum of two numbers is 17; twice the larger is 1 less than 3 times the smaller. What are the numbers?

The equation $2x=3(17-x)-1$ is true for the numbers in this problem but it illustrates no universal truth. This type of problem should rank at the bottom of the scale of values. Some teachers believe that such problems are indispensable at the start but the percentage problems, mentioned earlier, could be used instead. And as for training in reading, other problems serve the same purpose.

Smith is 6 times as old as Jones. In 12 years he will be 3 times as old as Jones. Find their ages now.

Success with this problem involves knowing that n years hence we will all be n years older. This universal truth is not important enough to merit emphasis. For this reason, rather than because it is "answer known" it ranks low in the scale.

Problems about digits hinge on knowing that a digit has 10 times the value it would have if moved one place to the right. The pupil can appreciate this important invention only by comparing our number system with other systems. But this is not done. For this reason, rather than because it is "answer known" it ranks low.

At the other end of the scale I place lever problems since they involve a universal principle. In too many texts these problems are placed later than they should be.

Rate of Work problems involve: Work done by A plus work done by B equals work done by A and B, and, Work done by A equals the number of hours he works times part done in 1 hour.

Mixture problems involve: The number of pounds of salt in one solution plus the number of pounds in a second equals the number of pounds of salt in the mixture.

Or, the value of one commodity plus the value of a second equals the total value of the two commodities.

Investment problems involve: The income from one investment plus the income from a second equals the total income.

Motion problems involve: $d=rt$, and such facts as that the distance from A to B is the same for all travelers. Likewise, problems about the resultant of two vectors, whether forces or velocities, should rank high.

Although the universal truths mentioned above seem commonplace, they are more significant than the fact that the sum of some numbers is another number. Too much time is spent on trivial problems.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1997, 8. *Belle Nickels, Columbia, S. C.*

1996. *Mason Turner, Columbia, S. C.*

1995, 6. *Henry Silverman, Brooklyn, N. Y.*

1995–8. *V. C. Bailey, Evansville, Ind.*

1996, 8. *George Grossman, New York City.*

1995, 6, 7, 8. *Francis L. Miksa, Aurora, Ill.*

1995, 7, 8. *M. Kirk, Media, Pa.*

1999. *Proposed by Hugo Brandt, Chicago, Ill.*

If the sides of a triangle are s_1, s_2, s_3 and the medians m_1, m_2, m_3

a) Calculate the medians in terms of the sides.

b) Calculate the sides in terms of the medians

Solution by Felix John, Philadelphia, Pa.

1. From Plane Geometry we have the theorem: In any triangle the sum of the squares of any two sides is equal to the sums of half the square of the third side and twice the square of the median to that side.

2. Using this theorem with the given notation we get

$$m_1=\tfrac{1}{2}\sqrt{2s_2^2+2s_3^2-s_1^2}$$

$$m_2=\tfrac{1}{2}\sqrt{2s_1^2+2s_3^2-s_2^2}$$

$$m_3=\tfrac{1}{2}\sqrt{2s_1^2+2s_2^2-s_3^2}$$

3. Solving the above equations for s_1, s_2, s_3, we get

$$s_1=\tfrac{2}{3}\sqrt{2m_2^2+2m_3^2-m_1}$$
$$s_2=\tfrac{2}{3}\sqrt{2m_1^2+2m_3^2-m_2^2}$$
$$s_3=\tfrac{2}{3}\sqrt{2m_1^2+2m_2^2-m_3^2}$$

Solutions were also offered by I. M. Gosz, W. DePere, Wis.; Norman Auning, University of Michigan, Clarence R. Perioho, W. S. Cook, Neb.; Sister Mary Dulciosa, Chicago; Martin Pearl, Brooklyn, N. Y.; Helen M. Scott, Baltimore, Md.; Burt McDuffie, New York City; Chas. W. Hansen, Brown Valley, Minn.; W. R. Warne, Dayton, Ohio; Hazel S. Wilson, Annapolis, Md.; Norma Sleight, Winnetka, Ill.; Margaret Joseph, Milwaukee, Wis.

2000. *Proposed by Mrs. Walter R. Warne, Columbia, Mo.*

Find the highest powers of 2 and 7, which are factors of 50!

Solution by Martin Pearl, Brooklyn, N. Y.

In 50! there are $\frac{50}{2}$ numbers divisible by 2 — 25 numbers

In 50! there are $\frac{50}{4}$ numbers divisible by 4 — 12 numbers

In 50! there are $\frac{50}{8}$ numbers divisible by 8 — 6 numbers

In 50! there are $\frac{50}{16}$ numbers divisible by 16 — 3 numbers

In 50! there are $\frac{50}{32}$ numbers divisible by 32 — 1 number

There are 47 2's in 50!

In 50! there are $\frac{50}{7}$ numbers divisible by 7 — 7 numbers

In 50! there are $\frac{50}{49}$ numbers divisible by 49 — 1 number

There are 8 7's in 50!

Hence 2^{47} and 7^8 are the highest powers of 2 and 7 which are factors of 50!

Solutions were also offered by Aaron Buchman, Buffalo, N. Y.; E. de la Garza, Brownsville, Texas; Belle Nickels, Columbia, S. C.; W. R. Smith, Passe a Grille Beach, Fla.; Helen M. Scott, Baltimore, Md.; Norman Auning, University of Mich.; Lyman J. Harris, Maryville, Tenn.; Karl M. Place, Dearborn, Mich.; Felix John, Philadelphia, Pa.

2001. *Proposed by Ray Dubish, Missoula, Mont.*

Prove the rule for squaring a number ending in 5, which follows:

Multiply the number with the 5 omitted by one more than this "shortened" number. To this product annex the number 25. The result is the square of the number.

Solution by Belle Nickels, Columbia, S. C.

Let n = the number with the 5 omitted, or the "shortened" number. Then $n+1$ = the number 1 greater, and $10n+5$ = the number to be squared.

$$(10n+5)^2 = 100n^2+100n+25 = 100n(n+1)+25.$$

Due to place value in the number system, to annex 25 to a product gives the same result as to add 25 to one hundred times the product.

$\therefore$ $100n(n+1)+25$ = the product of n and $(n+1)$ with 25 annexed, and is equal to the square of $(10n+5)$, the square of any number ending in 5.

Other solutions were offered by Felix John, Philadelphia, Pa.; Margaret Joseph, Milwaukee, Wis.; Norma Sleight, Winnetka, Ill.; E. de la Garza, Brownsville, Texas; Hazel S. Wilson, Annapolis, Md.; Walter L. Smith, Long Beach, Calif.; Elbert C. Weaver, Andover, Mass.; W. R. Smith, Passe a Grille Beach, Fla.; Ralph A. Edmondson, Marshall, Texas; Helen M. Scott, Baltimore, Md.; Martin Pearl, Brooklyn, N. Y.; James Grabiel, Elkhart, Ind.; and the proposer; R. H. Hoyle, Turlock, Calif.

2002. *Proposed by William Cox, Willard, N. J.*

Show that the 12th power of an integer is of the form $13m$ or $13m+1$.

Solution by Aaron Buchman, Buffalo, N. Y.

The easily proved simple Fermat theorem states that $a^{p-1} \equiv 1 \bmod p$ where a is any integer not divisible by p, a prime. Thus, for $p = 13$, and a not divisible by 13,

$$a^{12} = 1+13m \text{ where } m \text{ is an integer.} \tag{1}$$

Also, if a is divisible by 13,

$$a^{12} = 13m \text{ where } m \text{ is an integer.} \tag{2}$$

Since all values of a are included in either set (1) or set (2), the required relation has been proved.

Solutions were also offered by Felix John, Philadelphia, Pa.; N. Auning, University of Michigan; E. de la Garza, Brownside, Texas; Abraham L. Epstein, Asbury Park, N. J.; Helen M. Scott, Baltimore, Md.; Clarence R. Perisho, McCook, Neb.; Karl M. Place, Dearborn, Mich.

References: Dickson, Introduction to the Theory of Numbers, page 6; Hall and Knight's Higher Algebra, page 349; Chrystals Algebra, Part II, page 529.

2003. *Proposed by Hugo Brandt, Chicago.*

Solve for x:

$$(x^2-2)f(m^3) = f(m^3)+x, \quad \text{if} \quad f(m) = m+\frac{1}{m}.$$

Solution by the Proposer

The function $f(m)$ has the following properties

$$f(m^a)\cdot f(m^b) = f(m^{a+b})+f(m^{a-b}) \tag{1}$$

$$f(m^a)+f(m^b) = f(m^{(a+b)/2})\cdot f(m^{(a-b)/2}) \tag{2}$$

(2) follows from (1) and (1) can easily be verified by carrying out the multiplication.

Rearrange the given equation:

$$x^2f(m^3)-x = f(m^3)+2f(m^3).$$

Multiply by $f(m^3)$ and set

$$x \cdot f(m^3) = y \tag{3}$$

$$y^2 - y = f(m^5) \cdot f(m^3) + 2f(m^3) \cdot f(m^3)$$

and by (1)

$$y^2 - y = f(m^8) + f(m^2) + 2fm^6) + 2f(m^0)$$

$$\therefore \quad y = \tfrac{1}{2} \pm \sqrt{f(m^8) + 2f(m^6) + f(m^2) + 4\tfrac{1}{4}} = f(m^4) + f(m^2) - \tfrac{1}{2},$$

as can be verified.

$$\therefore \quad y = \tfrac{1}{2} \pm \left[f(m^4) + f(m^2) - \tfrac{1}{2} \right]$$

$$y_1 = f(m^4) + f(m^2) = f(m^3) \cdot f(m)$$

by (2)

$$y_2 = 1 - \left[f(m^4) + f(m^2) \right] = 1 - f(m^3) \cdot f(m).$$

Now from (3),

$$x = \frac{y}{f(m^3)}$$

and

$$x_1 = f(m) = m + \frac{1}{m}$$

$$x_2 = \frac{1}{f(m^3)} - f(m) = \frac{m^3}{m^6 + 1} - \left(m + \frac{1}{m} \right)$$

Solutions were also offered by Helen M. Scott, Baltimore, Md.; Felix John, Philadelphia, Pa.; Hazel S. Wilson, Annapolis, Md.; Abraham L. Epstein, Asbury Park, N. J.; and Martin Pearl, Brooklyn, N. Y.

2004. *Find the general solution of*

$$\left(4x^2 + y^2 \cos \frac{y}{x} \right) dx = xy \cos \frac{y}{x} \, dy.$$

Solution by Karl M. Place, Dearborn, Mich.

Let

$$y = xz$$

$$dy = xdz + zdx$$

$$4x^2 + x^2z^2 \cos z = zx^2 \cos z \left(x \frac{dz}{dx} + z \right)$$

$$4x^2 + z^2x^2 \cos z = zx^2 \cos z \frac{dz}{dx} + z^2x^2 \cos z$$

$$4x^2 = zx^2 \cos z \frac{dz}{dx}$$

$$\frac{4dx}{x} = z \cos z dz.$$

Let $z = u \cos z dz = dv$ and integrate right hand number by parts.

$$4 \log x = \cos z + z \sin z + c$$

Substituting

$$z = \frac{y}{x}$$

$$4 \log x = \cos \frac{y}{x} + \frac{y}{x} \sin \frac{y}{x} + c.$$

Solutions were also offered by Jack D. McDaniel, Garber, Okla.; Hazel S. Wilson, Annapolis, Md.; R. J. Hoyle, Turloch, Calif.; Helen M. Scott, Baltimore, Md.; Clarence R. Perisho and the proposer.

Note. A few solutions were obtained by use of the substitution $u = y/x$.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

1995. *Blair Turner and Eugene Woodward—both from Dreher H. S., Columbia, S. C.*

2000, 1. *Ben Miller, Northbrook, Ill.*

2001. *Al Cappelen, Northbrook, Ill.; Mary L. Pelzer, Davison, Mich.*

2017. *Proposed by W. Nicholson, Chicago.*

Show that the pth power of an integer, n, is equal to the sum of n consecutive integers of the form $4k \pm 1$, k an integer.

2018. *Proposed by Norman Anning, University of Michigan.*

Solve:

$$A + B + C = 180^\circ$$

$$14 \cos A = 22 \cos B = 77 \cos C.$$

2019. *Proposed by V. C. Bailey, Delaware, Ohio.*

The perpendicular bisector of the line joining the feet of two altitudes of a triangle bisects the third side of the triangle.

2020. *Proposed by V. C. Bailey, Delaware, Ohio.*

In triangle ABC, if a, b, c, and h_b are consecutive integers with $a > b > c$, find a, b, c, and h_b.

2021. *Proposed by Philip Haber, New York City.*

A man is given 100 coins totaling \$43.05 to buy stationery as follows: a erasers at 1¢ each, b rulers at 5¢, c notebooks at 10¢, d compasses at 25¢, e pencils at 50¢ and f pens at \$1.00. How many items of each can be bought?

2022. *Proposed by L. Jacobus, Kinderbook, N. Y.*

The sides of a triangle are 5, 19 and 21 in length. Show that the angles are in arithmetic progression and that the common difference is arc cos 13/19.

BOOKS AND PAMPHLETS RECEIVED

MECHANICAL DRAWING, by Fred Nicholson, *Head of Academic Division, Henry Ford Trade School, Dearborn, Michigan.* Cloth. Pages vii+211. 18×25 cm. 1946. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price \$2.00.

A TEXTBOOK OF QUALITATIVE ANALYSIS, by William Buell Meldrum, *Professor of Chemistry, Haverford College, Haverford, Pennsylvania*, and Albert Frederick Daggett, *Professor of Chemistry, University of New Hampshire, Durham, New Hampshire*. Cloth. Pages xi+431. 14×22 cm. 1946. American Book Company, 88 Lexington Avenue, New York, 16, N. Y. Price $3.50.

OUR BIG WORLD, by Harlan H. Barrows, *Department of Geography, University of Chicago, Chicago, Illinois*; Edith Putnam Parker, *Department of Geography, University of Chicago, Chicago, Illinois;* and Clarence Woodrow Sorensen, *Traveler and Geography Lecturer*. Cloth. Pages v+186. 20×27 cm. 1946. Silver Burdett Company, 221 East 20th Street, Chicago 16, Ill.

THE AMERICAN CONTINENTS, by Harlan H. Barrows, *Department of Geography, University of Chicago, Chicago, Illinois;* Edith Putnam Parker, *Department of Geography, University of Chicago, Chicago, Illinois;* and Clarence Woodrow Sorensen, *Traveler and Geography Lecturer*. Cloth. Pages v+314. 20×27 cm. 1946. Silver Burdett Company, 221 East 20th Street, Chicago 16, Ill.

FROM GALILEO TO THE NUCLEAR AGE, by Harvey Brace Lemon, Ph.D., *Professor of Physics, The University of Chicago; Curator of Physics, Museum of Science and Industry, Chicago*. Revised Edition of *From Galileo to Cosmic Rays*. Cloth. Pages xi+451. 16.5×23 cm. 1946. The University of Chicago Press, 5750 Ellis Avenue, Chicago 37, Ill. Price $3.75 Text Edition; $5.00 Trade Edition.

ELECTRICAL ENGINEERING, by Fred H. Pumphrey, *Educational Service Division, General Electric Company*. Cloth. Pages xii+369. 14.5×23 cm. 1946. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $5.35.

TELECASTING AND COLOR, by Kingdom S. Tyler. Cloth. Pages viii+213. 14×21.5 cm. 1946. Harcourt, Brace and Company, 383 Madison Avenue, New York 17, N. Y. Price $2.75.

ELEMENTS OF MACHINES, by Frank L. Verwiebe, *Research Associate, Army Institute;* Elmer E. Burns, *Teacher of Physics (Emeritus), Austin High School, Chicago;* and Herbert C. Hazel, *Major, U. S. Marine Corps*, Cloth. Pages x+222. 15×23 cm. 1943. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y.

SCIENCE, by D. W. Hill, D.Sc. Cloth. Pages v+114. 13.5×21.5 cm. 1946. The Chemical Publishing Company, Inc., 26 Court Street, Brooklyn 2, N. Y. Price $2.75.

CHEMICAL SPECIALTIES. A Symposium Compiled by H. Bennett, *Technical Director, Glyco Products Company, Inc.* Cloth. Pages xiv+826. 13.5×21.5 cm. 1946. The Chemical Publishing Company, Inc., 26 Court Street, Brooklyn 2, N. Y. Price $12.50.

THE KNOWLEDGE OF PREREQUISITE ALGEBRA POSSESSED BY STUDENTS OF COLLEGE ALGEBRA, by Jacob S. Orleans, *Associate Professor, Education Department*, and Russell Loucks, *Instructor, Mathematics Department, The City College of New York*. The City College Research Studies in Education, Number 3. Paper. 79 pages. 13.5×21.5 cm. 1946. The School of Education, The College of the City of New York, New York, N. Y.

ARITHMETIC: DEVELOPING AN UNDERSTANDING OF PLACE VALUE IN

THE ARITHMETIC PROGRAM OF THE LOWER ELEMENTARY GRADES, by H. Van Engen, *Iowa State Teachers College*. Paper. 10 pages. 15.5×23 cm. Issue No. 2. October 1946. Irving H. Hart, Director of Extension Service, Iowa State Teachers College, Cedar Falls, Iowa. Price 10 cents.

OFFICE OF RESEARCH AND INVENTIONS. A Statement of Policy and Organization. Paper. 20 pages. 15×23.5 cm. 1946. Navy Department, Office of Research and Inventions, Washington, D. C.

THE USE OF RESEARCH BY PROFESSIONAL ASSOCIATIONS IN DETERMINING PROGRAM AND POLICY, by Esther Lucile Brown, *Director, Department of Studies in the Professions, Russell Sage Foundation*. Paper. 39 pages. 15×22.5 cm. 1946. Russell Sage Foundation, 130 East 22nd Street, New York 10, N. Y. Price 25 cents.

RADIO AND ITS CRITICS. Address by William S. Paley, *Chairman of the Board of the Columbia Broadcasting System*, Delivered before the Twenty-Fourth Annual Convention of the National Association of Broadcasters, Chicago, Illinois, October 22, 1946. Paper. 29 pages. 17×22 cm. Columbia Broadcasting System, 485 Madison Avenue, New York 22, N. Y.

ANALYSIS OF WORLD SITUATION ON SUGAR AND UNITED STATES SUPPLIES AND REQUIREMENTS, by Food Industry Council Sugar Committee, Edwin O. Blomquist, *Chairman*. Paper. 32 pages. 21.5×28 cm. November 1946. Food Industry Council, 1029 Vermont Avenue, N.W., Washington 5, D. C.

ERRATUM: In our December issue a review was given of the book, *Brazil, Orchid of the Tropics*, published by The Jaques Cattell Press of Lancaster, Pennsylvania. The publisher was erroneously given as The Science Press.

BOOK REVIEWS

ELEMENTARY APPLIED AERODYNAMICS, by Paul E. Hemke, *Professor of Aeronautical Engineering, Rensselaer Polytechnic Institute*. Cloth. Pages viii+231, 15×23 cm. 1946. Prentice-Hall, Inc. 70 Fifth Avenue, New York 11, N. Y. Price $3.25.

This new text in the field of aerodynamics presents a concise introduction to technical applied aerodynamics. It is quite suitable for a semester course to introduce the engineering student to the specialized principles that must be mastered by the aerodynamic engineer. It presupposes adequate training in mathematics through the calculus, as well as thorough courses in physics and mechanics.

The principles are presented both descriptively and with thorough analytical treatment and adequately illustrated with photographs, diagrams and curves. The usual topics of fluid flow and airfoil dynamics in two and three dimensional flow are adequately covered. Viscosity effects on the characteristics of airfoils are also discussed. The various problems of propeller design and performance are thoroughly presented. The many problems of performance of the conventional type airplane are treated analytically. An introductory chapter on rotors and helicopters directs the student toward a timely field. All of the topics are well illustrated with problems for student solution.

Instructors in this field who have been preparing their own extractions from more advanced texts for presentation in an elementary course will do well to consider this text, which is the result of the author's experience in teaching the material here presented.

H. R. VOORHEES
Chicago City College, Herzl Branch

PHYSICS, by Walter G. Whitman, *Formerly Head, Physical Science Department, State Teachers College, Salem, Massachusetts;* and A. P. Peck, *Managing Editor, Scientific America, New York, N. Y.* Cloth. Pages viii+629. 15×22 cm. 1946. American Book Company, 88 Lexington Avenue, New York 16, N. Y. Price $3.00.

Mr. Whitman, who is already noted for his many excellent books with a practical slant, and Mr. Peck, the editor of a leading scientific magazine have, as might be expected, combined to produce a book which is heavy on the side of the *applications* of physics.

The authors state in their preface that "The physics of today must explain those fundamental facts and principles upon which invention, discovery, and the progress of science depend. At the same time, it should help young people to see the relation between the science of the classroom and the activities of everyday life." The reviewer agrees that it "does both of these things."

Many illustrations are used and the modern trend of employing high grade photographs bled out to the edge of the pages is followed.

An innovation is, that following each chapter the authors have included one or more related "sidelights." These usually "record some step in the development of science or point out some unusual application;—their purpose is to excite the interest and pique the curiosity" of the student.

In addition to the usual review exercises and problems, non mathematical exercises are included for "clear thinking."

"The organization of text and teaching materials is such as to provide an extremely flexible course.—The variety and flexibility of the materials in this text make it equally suitable for the general student whose formal education may end with the high school, and—for the college preparatory student." This reviewer is not completely convinced that it is "equally suitable" for the requirements of the college preparatory student.

The book is well and interestingly written. It is modern to the last minute and follows the late trend of including a unit on electronics, which includes a chapter on "Free Electrons at Work," one on "Radio Transmission and Reception" and one on "Television." The chapter on television is particularly well done. It is to be regretted that the one year physics course does not permit sufficient time to devote to the subject of electronics. The user of this book will probably find that although this excellent unit on electronics is included it will be neglected in the course since it comes at the end of the book and the other portions of the text will not be completed in time to treat this subject adequately.

The practical units on "Physics on the Road," "Man Conquers the Air," and "Photography" might be omitted if time is pressing but the outstanding practical value of the book would be largely lost.

The book is divided into the following twelve units: (1) Physics in Our Daily Life, (2) The Behaviour of Molecules, (3) Fluids Aid in the World's Work, (4) Force and Motion, (5) Heat, (6) Physics on the Road, (7) Man Conquers the Air, (8) Sound, (9) Light, (10) Photography, (11) Magnetism and Electricity, (12) Electronics.

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